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Engineering Report for WC-130J Stepped Frequency Microwave Radiometer Integration Study

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1.0 Study Description

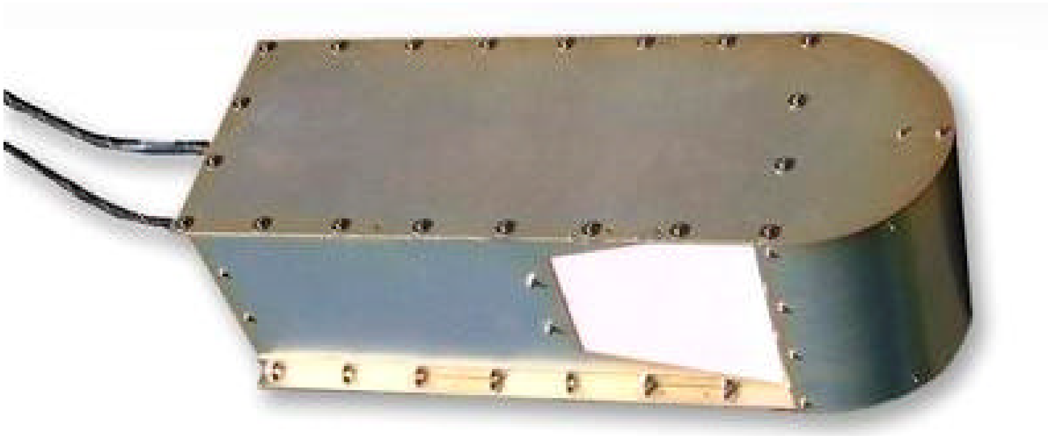
This report details the results of an engineering study conducted under contract F33657-95-C-2055, amendment P00056 for the WC-130J program. The study evaluates the integration of a Stepped Frequency Microwave Radiometer (SFMR) sensor subsystem on the WC-130J aircraft. The SFMR measures ocean surface brightness temperature. The brightness measurements are used to estimate the emissive of the ocean surface and derive estimates of wind speed, wind stress and rainfall rate. The SFMR sensor subsystem is currently flown and operated on a NOAA P-3 aircraft.

The National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS) Tropical Storm Prediction Center in Miami, Florida, have established a need for Air Force Reserve Command (AFRC) WC-130J aircraft to be equipped with the SFMR. This study evaluates the feasibility of safely and suitably installing the SFMR sensor subsystem on the WC-130J aircraft. In addition, this study evaluates the integration of the Aerial Reconnaissance Weather Officer (ARWO) computer/software with a SFMR sensor subsystem. The data for the SFMR sensor subsystem to support this study was provided from the University of Massachusetts through coordination with the government.

The tasks to be performed under this study are outlined below:

1. Conduct feasibility study to evaluate the technical and logistical aspects on installing the SFMR sensor on the WC-130J aircraft.
2. Evaluate potential effect to WC-130J aircraft performance, structure, avionics and electrical systems.
3. Evaluate potential safety issues with respect to penetrating the pressure vessel and aerodynamic loads.
4. Evaluate potential electromagnetic interference to and from other aircraft systems, including WC-130J peculiar systems.
5. Integrate the ARWO computer/software to process data from the SFMR sensor subsystem.
6. Modify the ARWO software to add SFMR based data into weather meteorological messages transmitted over Satellite Communications (SATCOM) link.
7. Evaluate the potential effect to ARWO computer resources.
8. Evaluate reliability and maintainability aspects of the system.
9. Determine if any special support equipment will be required.

2.0 SFMR Description



Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 1 – Stepped Frequency Microwave Radiometer (SFMR)

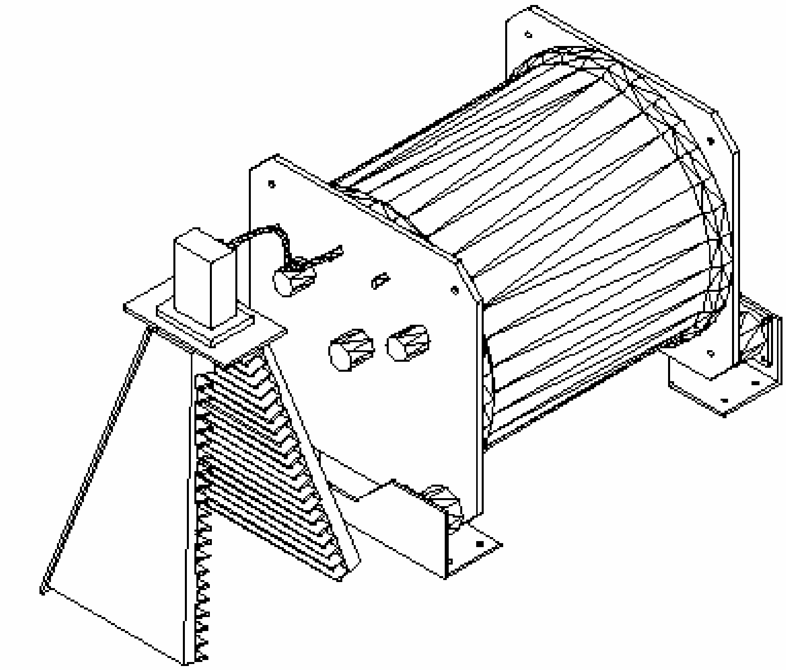
The Stepped Frequency Microwave Radiometer (SFMR) is a compact, airborne radiometer designed to measure surface brightness temperature in 8 frequency bands spanning 5 to 7 GHz. Calibrated values of brightness temperature generated by the SFMR are transmitted real time and processed using an algorithm that generates a real time measure of surface level wind speed and rain rate in hurricanes and tropical storms. It has been used aboard National Oceanic and Atmospheric Administration (NOAA) hurricane reconnaissance aircraft since it was developed in the mid 1990's. The system shown above was built for the US Naval Research Laboratory as part of a multi sensor imaging system.

- Wide Band (4.6 – 7.2 GHz) receiver
- Dipole array or horn antenna
- Capable of measuring winds to 50 m/s with accuracy of 1 m/s every 5 seconds
- System control and data acquisition via RS-422 port of IBM compatible computer
- Many system parameters adjustable in-flight via software commands to systems imbedded controller
- Microprocessor-based thermal control maintains receiver and dipole array antenna at constant temperature
- Waterproof enclosure

Source: ProSensing, Inc. 2002, www.prosensing.com

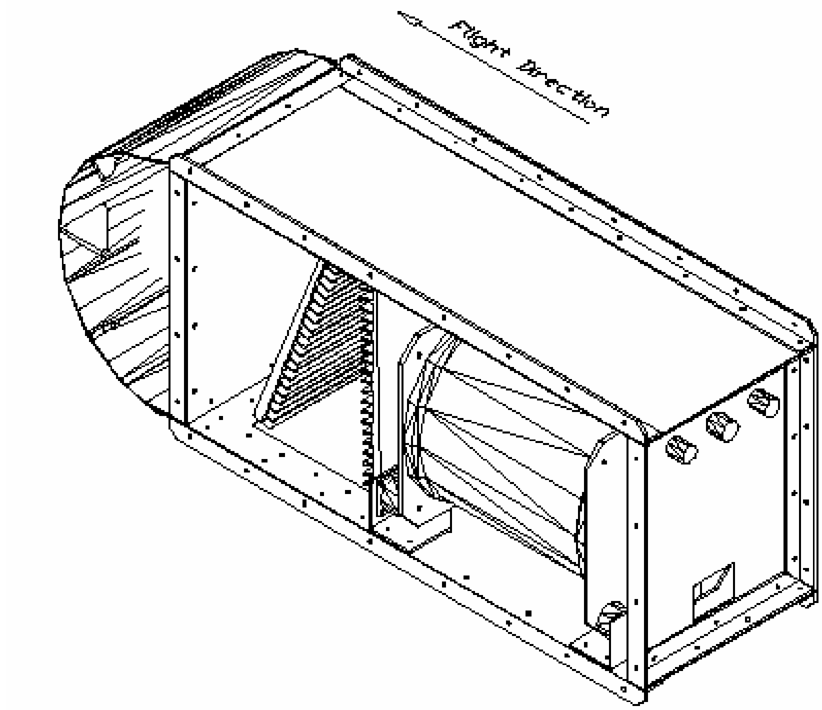
Table 1 - Standard SFMR Features

2.1 SFMR Outline Drawing



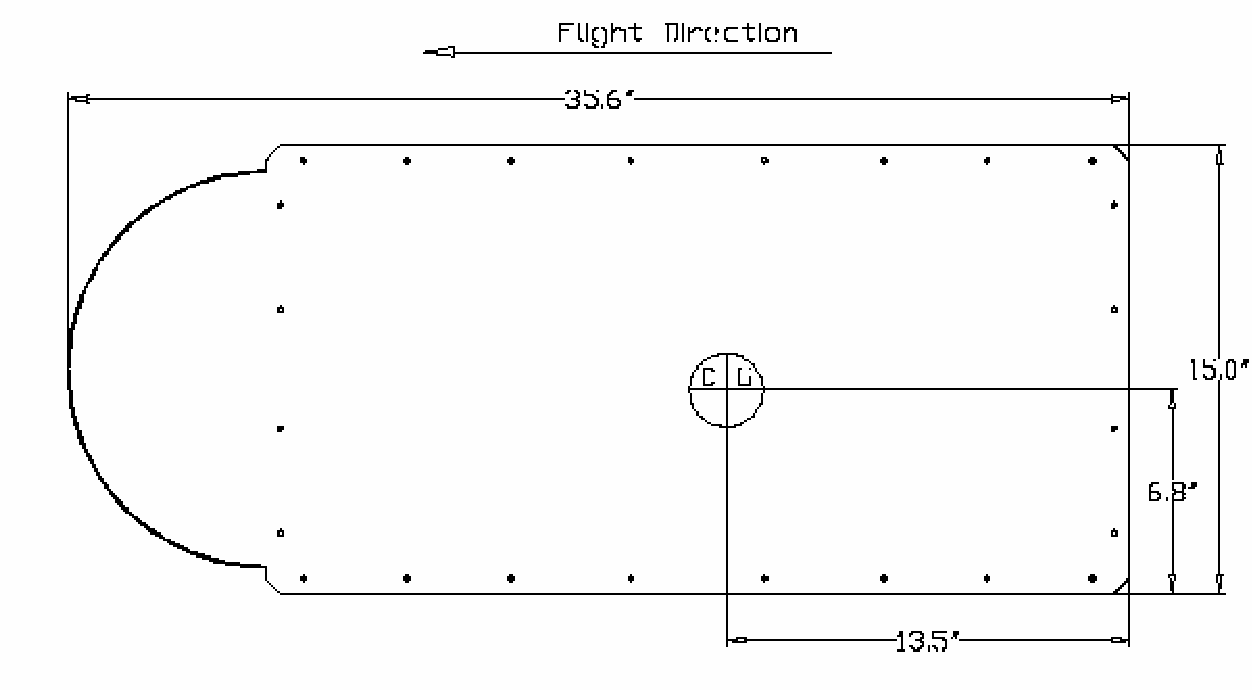
Source: ProSensing, Inc. 2002, www.prosensing.com

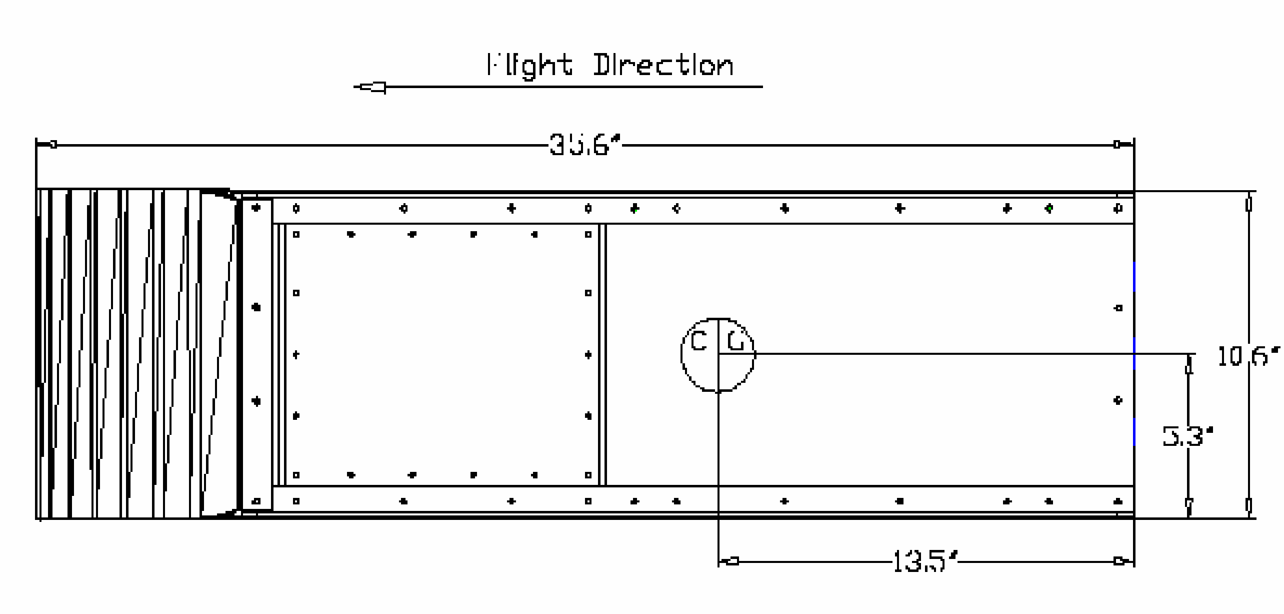
Figure 2 – SFMR Corrugated Horn and Receiver Enclosure



Source: ProSensing, Inc. 2002, www.prosensing.com

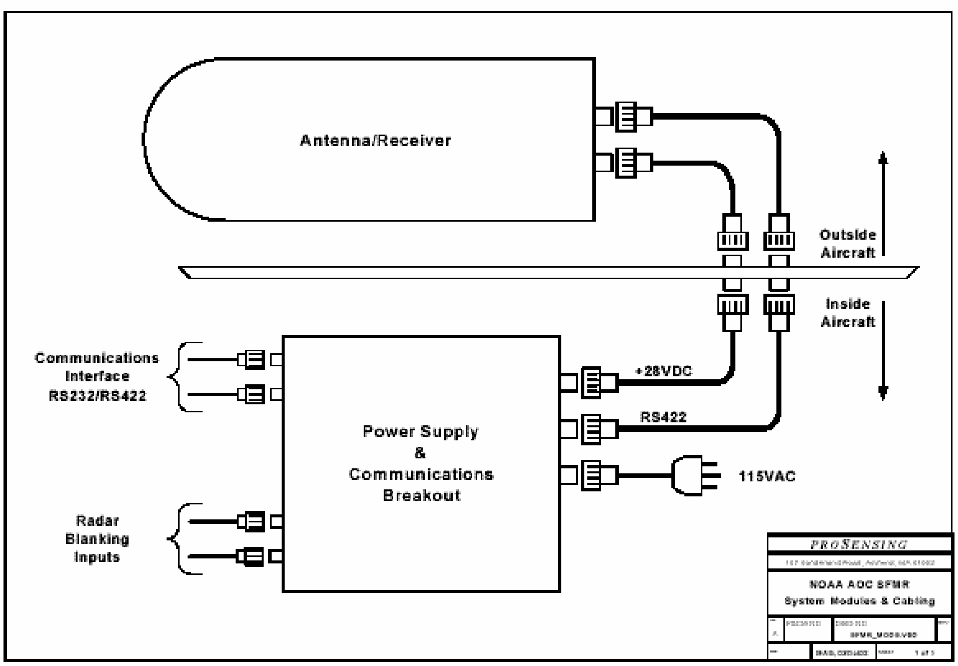
Figure 3 – SFMR Antenna and Receiver Mounted Inside Fairing





Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 4 – SFMR Outline Dimensions and Center of Gravity



Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 5 – SFMR System Modules and Cabling

2.2 SFMR Specifications

Specifications

• Radiometer Type:	Hatch
• Tuning Bandwidth:	4.6 – 7.2 GHz
• Number of Channels:	Up to 8
• Receiver Channel Bandwidth:	50 MHz
• Antenna Type:	Corrugated Horn
• Antenna Beamwidth (3 dB):	20 – 28 deg (Over the Tuning Bandwidth)
• Polarization:	Linear
• Cross-Polarization Isolation:	25 dB
• Front End Loss:	0.2 dB
• System Noise Temperature:	224 K @ 35C (Noise Figure = 2.3 dB)
• Measurement Precision:	0.17 K (1s Averaging)
• Electronics Power Requirements:	28 VDC, 2 A
• Thermal Control Power Requirements:	28 VDC, 4 A (Max)
• Power:	168 W
• Operating Temperature:	-65 deg C to +40 deg C
• Humidity:	0 to 100%
• Size (L x W x H):	32” x 14” x 9”
• Weight:	40 lbs.

Source: ProSensing, Inc. 2002, www.prosensing.com

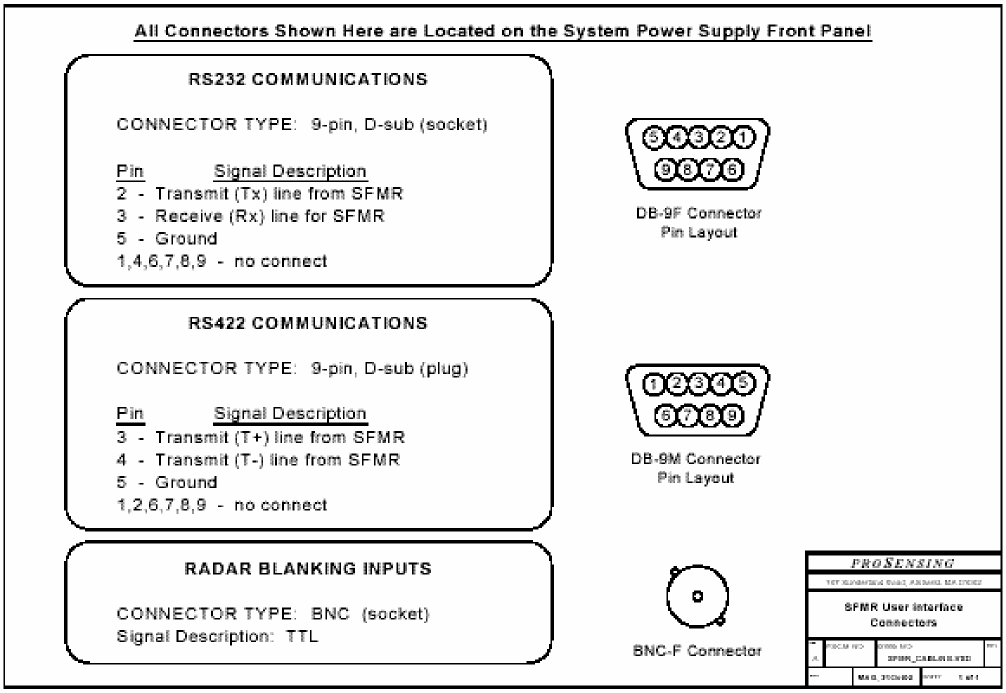
Table 2 – SFMR Specifications

2.3 SFMR Structural Interface

The SFMR unit is delivered in a sealed weather hardened case built from aluminum angles, sheet and extrusions. Numerous fastener locations exist along the top and bottom of this case, which can be utilized or modified to provide attachments for a quick connection system for mounting the unit into position on the aircraft.

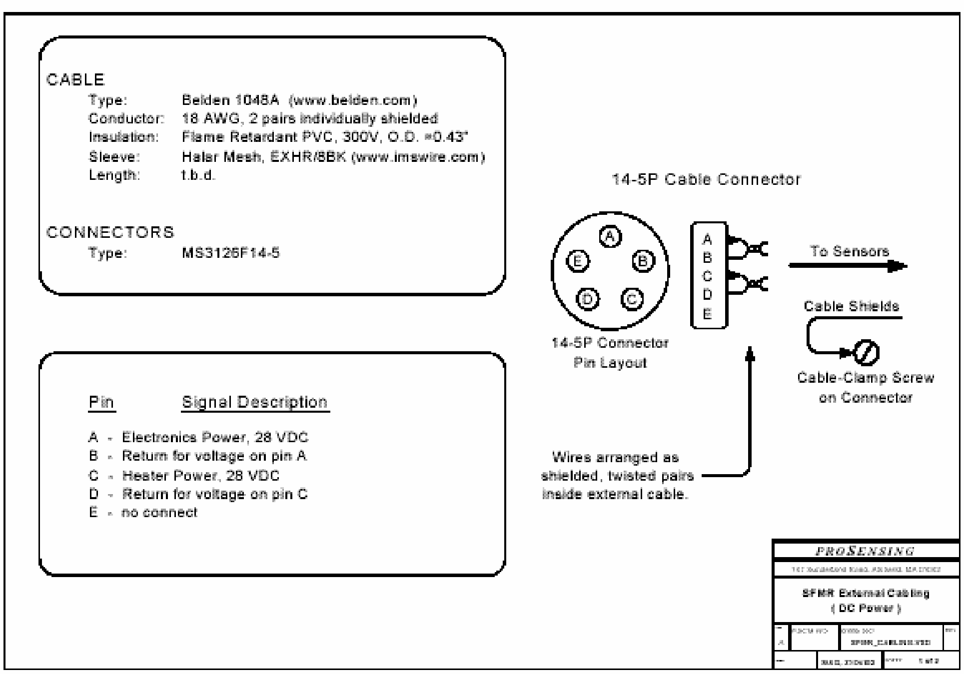
The present SFMR unit design installs the system components shock mounted in the hard case. This arrangement has been used successfully on the present NOAA aircraft. While this is certainly encouraging for our proposed installations the significant differences in the operational characteristics of the existing NOAA fleet from those of the WC-130J will require a testing/certification program for be conducted by Prosensing to qualify the SFMR unit for use on theWC-130J by Lockheed Martin.

2.4 SFMR Electronic Interface

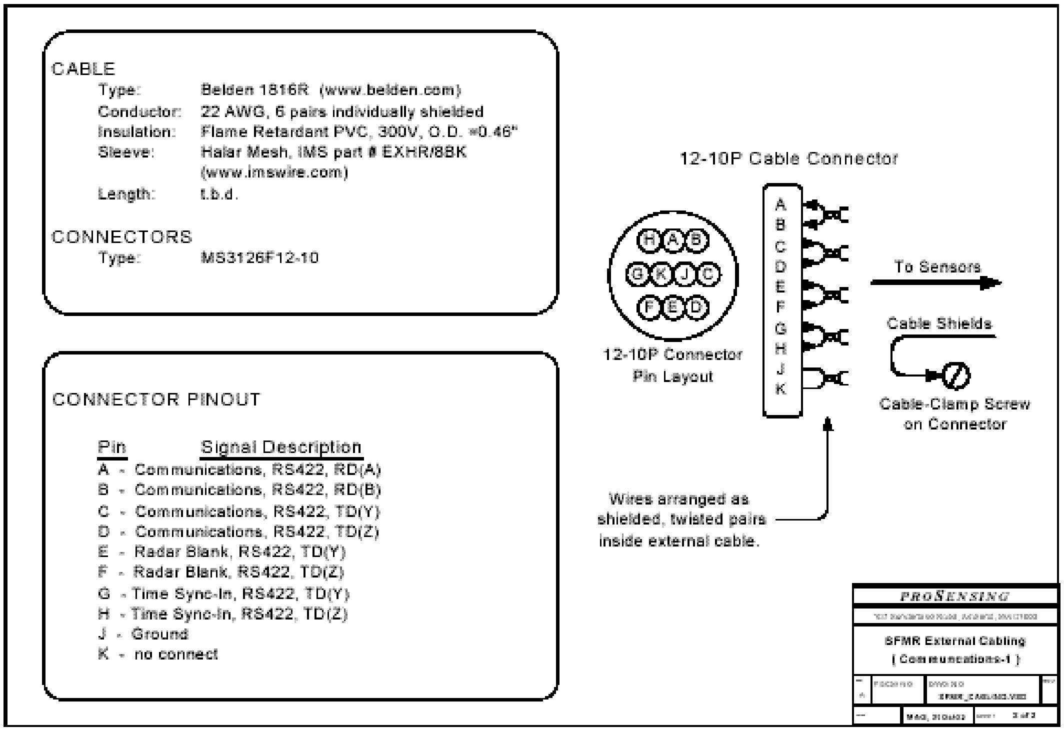


Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 6 – SFMR User Interface Connector Description

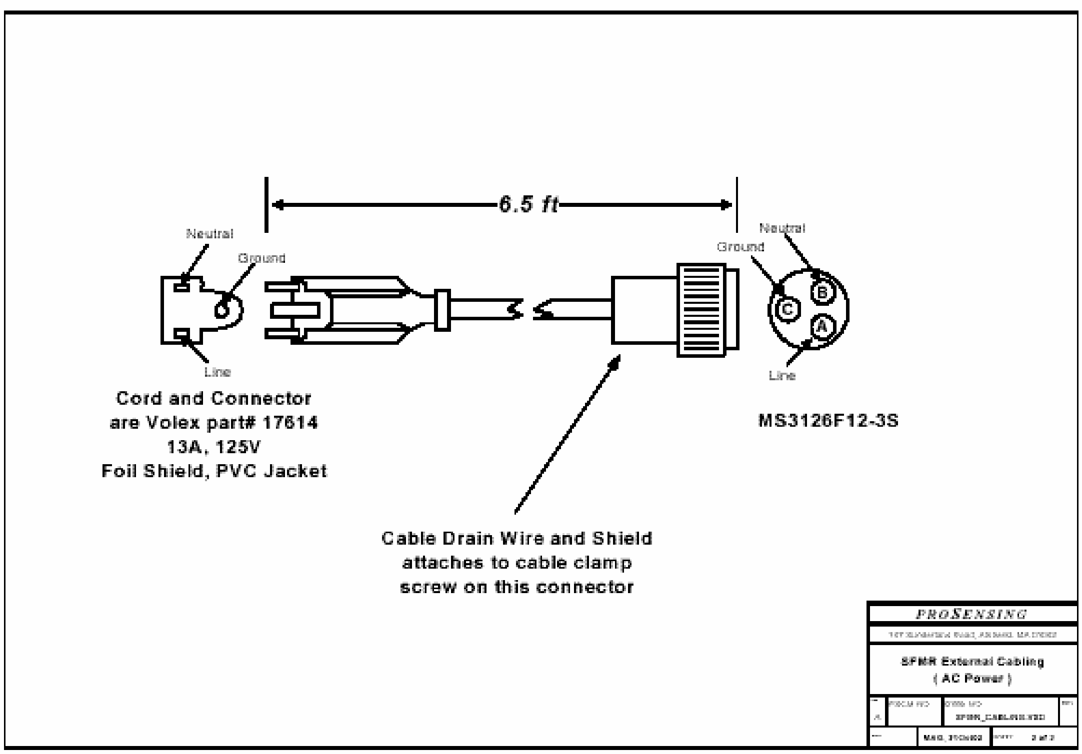


Source: ProSensing, Inc. 2002, www.prosensing.com



Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 7 – SFMR External Communications Cable Description



Source: ProSensing, Inc. 2002, www.prosensing.com

Figure 8 – SFMR External AC Power Cable Description

2.5 SFMR Operational Requirements

2.5.1 Preflight Requirements

The SMFR requires a visual inspection prior to flight to insure that the Rexolite antenna radome is neither damaged nor obstructed by contaminants (fuel, oil, etc.). Also required would be for Prosensing to provide a calibration procedure to setup units that have been removed and reinstalled to verify that the reinstalled unit is functioning properly.

2.5.2 Thru-Flight Requirements

The SMFR unit requires an initial 30-minute warm-up period. This starts the moment the unit is switched on and should pose no operational burden on the aircraft as it should be accomplished during the aircraft's engine run-up and take-off phases of its' mission.

2.5.3 Post-Flight Requirements

The SMFR requires a visual inspection after each flight to insure that the Rexolite antenna radome or installation has not been damaged nor the lens obstructed by contaminants (fuel, oil, etc.).

2.5.4 Periodic Maintenance Requirements

Prosensing did not provide MTBF or MTTR information for this report and as of this date does not plan any testing to provide this data. They plan at this time to rely on the past performance of the three units presently in service with NOAA to serve as baseline for their reliability – to date they have not had a in-flight failure of the unit. All of the proposed installation configurations will offer considerably more protection in service than the present P-3 installations. As far as maintenance requirements are concerned the unit will require, per Prosensing, to be returned to them yearly for calibration and additionally the unit will require nitrogen purging which can be performed by the owner/operator.

As the SFMR unit as shown by Prosensing at this time is a sealed sensor package it should not require any special ground equipment for its service. Therefore the only support equipment, which might be required, would be to support the new structural elements created to install the unit. In most of the installations to be considered in this report that amounts to new support cradles for support lifts to coordinate with the various pod and pylon configurations.

In the event that the unit is removed and reinstalled by the operator, there has yet to be written a procedure to allow for recalibrating and verifying the accuracy of the SFMR unit. This will have to be addressed by Prosensing and the operator.

3.0 ARWO Software Integration Study Results

3.1 ARWO Computer Architecture

The section identifies the architecture of the ARWO computer to support the interface with a SFMR sensor subsystem. The SFMR sensor subsystem evaluated during this study was based upon the SFMR sensor utilized on the NOAA P-3 aircraft. The data and interface information to support this study was provided by the University of Massachusetts. The SFMR sensor provides a serial asynchronous RS-232 interface for the exchange of data processed/computed by the SFMR sensor. Figure 9 below depicts the interface between the ARWO computer and the SFMR sensor subsystem.

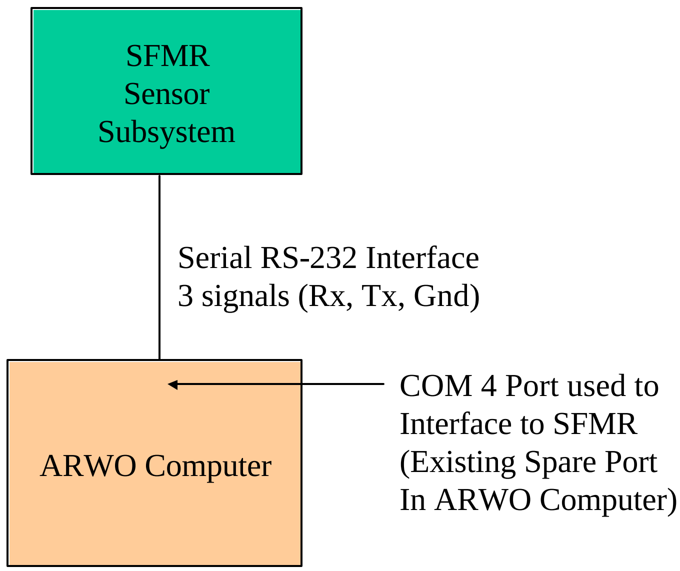


Figure 9 – ARWO Computer – SFMR Interface Diagram

The ARWO computer currently in use on the WC-130J aircraft has 4 serial asynchronous RS-232 interfaces. Of these 4 serial RS-232 ports, only 3 are used. Table 3 shown below depicts the uses of the serial interfaces within the ARWO computer.

Table 3 – ARWO Computer Serial COM Port Usage

Serial Port	Interface Connection	Interface Usage
COM 1	ARWO ⇒ AVAPS	1Hz transfer of Aircraft Platform data
COM 2	AVAPS ⇒ ARWO	DROP message transfer
COM 3	ARWO ⇒ VDC-300	Weather meteorological message transfer to VDC-300 / ARC-210 Data port
COM 4	SFMR ⇒ ARWO	SFMR Sensor data transfer (New)

This COM 4 port is one of two serial ports on the serial COM port Industry Standard Architecture (ISA) card. This two serial port ISA card is the Model SPRT2B/AT card. The COM 1 and COM 2 ports are contained on the Single Board Computer (SBC) card, and the COM 3 port is contained on this ISA card, Model SPRT2B/AT. The ARWO computer architecture is depicted in Figure 10 below.

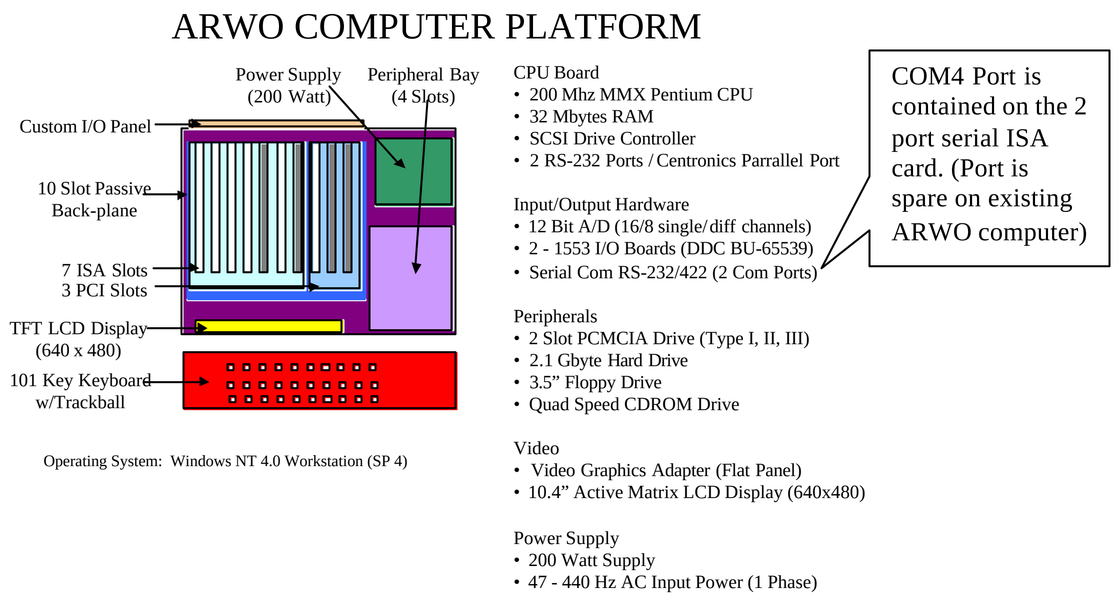


Figure 10 – ARWO Computer Platform Architecture

The current production configuration for the ARWO computer was modified to enable COM 4 port. One of the two existing prototype ARWO computers maintained in the production configuration was utilized. The COM 4 port was enabled and configured (i.e., the Interrupt Request (IRQ), Input/Output (I/O) address) into the computer. The Table 4 below identifies the configuration of the COM ports within the ARWO computer.

Table 4 – ARWO Computer Serial COM Port Configuration

Serial Port	I/O Port	Interrupt Request (IRQ)
COM 1	3F8	4
COM 2	2F8	3
COM 3	3E8	10
COM 4	2E8	10

The COM 4 port configured into the ARWO computer was set to share IRQ 10 with COM 3 port. Executing the modified ARWO Mission Manager application on the target ARWO computer with COM 4 port enabled and configured tested this configuration. This testing was conducted with the added functionality to monitor the SFMR data being received through the COM 4 port.

3.1.1 Alternative ARWO Computer Architectures

In addition to this configuration, if and when the ARWO computer is modified to support Satellite Communication (SATCOM) Controller software executing within the ARWO computer, an additional IRQ will be available. This alternative ARWO computer configuration could be utilized as well. This alternative configuration for the ARWO computer was also tested during this study. The potential ARWO computer configuration to support SATCOM control along with the interface to support SFMR sensor processing is depicted in Figure 11 below.

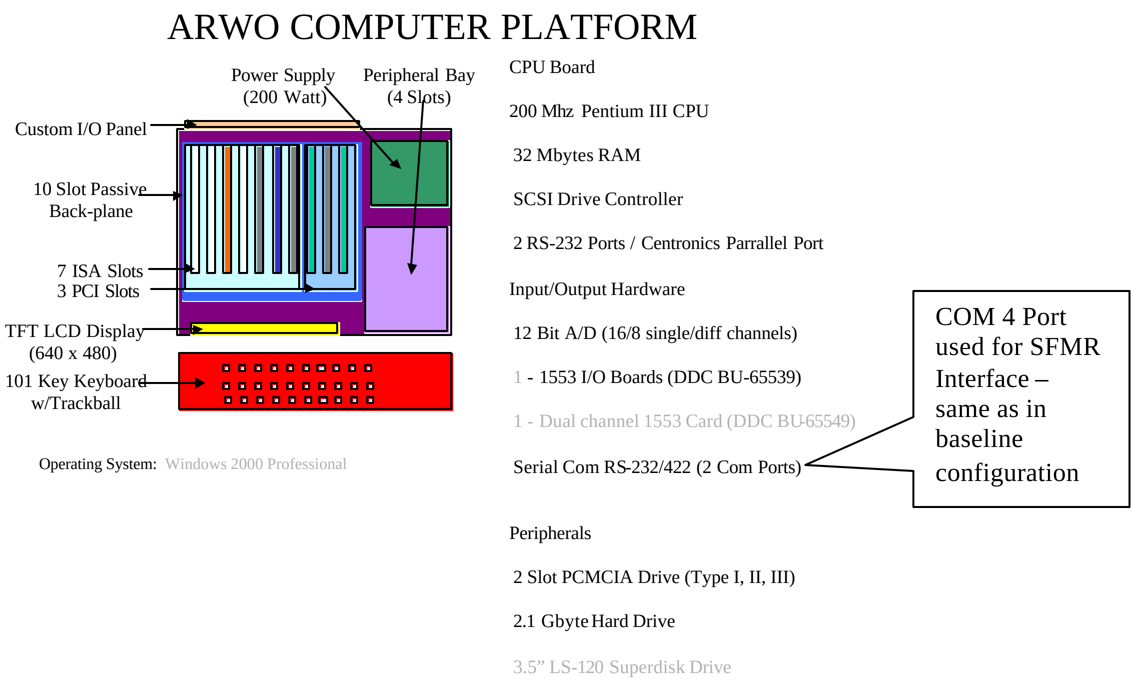


Figure 11 – Alternative ARWO Computer Platform Architecture

In this upgraded/alternative ARWO computer configuration, the removal of one of the 1553 ISA cards (model BU-65539) frees up an IRQ. Hence, the IRQ configuration for this upgraded/alternative ARWO computer could be as is listed in the Table 5 below. This table shows that Serial COM 4 is no longer sharing IRQ 10 with Serial COM 4, but rather is using IRQ 7 which in the baseline ARWO computer configuration was used by one of the two 1553 ISA cards.

Table 5 – Alternative ARWO Computer IRQ Configurati on

Interrupt Request (IRQ)	Resource
01	I8042prt
03	Serial COM 2
04	Serial COM 1
05	ISA 1553 Card
06	Floppy

Interrupt Request (IRQ)	Resource
07	Serial COM 4
09	Dual PCI 1553 Card
10	Serial COM 3
11	Symc8xx
12	I8042prt

3.2 SFMR Interface

The SFMR sensor subsystem has a serial asynchronous RS-232 interface for the transfer of data and status. The SFMR sensor subsystem outputs data in American Standard Committee for Information Interchange (ASCII) format at either a 1 or 2 Hz rate. The primary weather meteorological data items that the SFMR sensor computes is rain fall rate and surface wind speed. In addition, to this data the SFMR provides status on each of the 6 channels of its receiver. The total set of data output by the SFMR sensor subsystem evaluated under this study is depicted in the Table 6 below.

Table 6 – SFMR Sensor Data Output

Data Element	Data Type	Units
Time	Real	Seconds
Surface Wind Speed (SWS)	Real	m/sec
Rainfall rate (RR)	Real	mm/hr
RMS Error	Real	N/A
Frequency	Integer	N/A
Roll/Pitch Validity	Boolean	N/A
Brightness Temperatures for each channel Tb[0]…Tb[5]	Real	kelvin
Gain for each channel Gain[0]…Gain[5]	Real	N/A
Offset for each channel Offset[0]…Offset[5]	Real	N/A
Thermistor Reading for each channel Temp[0]…Temp[5]	Real	N/A
Message Delimiter	'N'	N/A

3.3 Test Environment / Simulation

The ARWO software was modified to process the data output by the SFMR sensor subsystem. The modifications to the ARWO software, Mission Manager application, were tested utilizing a simulation of the SFMR sensor output. This SFMR sensor simulation was developed by the University of Massachusetts, and provided to Lockheed Martin. The receipt of this simulation software was coordinated with the government. This SFMR simulation was a 32-bit windows C++ executable. This SFMR simulation software would process a binary data file that was generated during an operational hurricane mission. This binary data file was generated from an actual operational SFMR sensor subsystem installed on a NOAA P-3 aircraft. The binary data file was generated during an operational hurricane mission flown through Hurricane Brett on September 21, 1999.

The SFMR simulation software was installed on a desktop computer, and interfaced to the ARWO computer via a 9-pin serial interface cable (i.e., null modem cable). The modified ARWO software was installed on the ARWO computer with COM 4 now being configured and processed by the ARWO software. The SFMR simulation software could be configured to use a specific COM port, and the baud rate, transfer rate, and number of stop bits and parity bits selectable within the simulation software. The SFMR simulation software was configured to output data at a 1Hz rate at 9600 baud, using 8 data bits, 1 stop bit, and no parity. The ARWO software likewise configured COM 4 port to accept data at a 9600 baud, using 8 data bits, 1 stop bit and no parity.

3.4 ARWO Software Modifications

The ARWO software was modified to perform the processing of the data output by the SFMR simulation. The additional SFMR data was added into the processing logic for most of the weather meteorological messages generated by the ARWO software. In addition, the Surface Wind Speed (SWS) and Rainfall Rate (RR) were added to the mission variable set processed and recorded by the ARWO software. The details of the ARWO software modifications are outlined in the following sub-paragraphs.

3.4.1 ARWO Software COM 4 processing

A serial COM port object was added to the main form of the Mission Manager application. This COM port object was configured and setup to process data coming into the COM 4 port within the ARWO computer. The design view of the ARWO Mission Manager main form is depicted in the Figure 12 below.

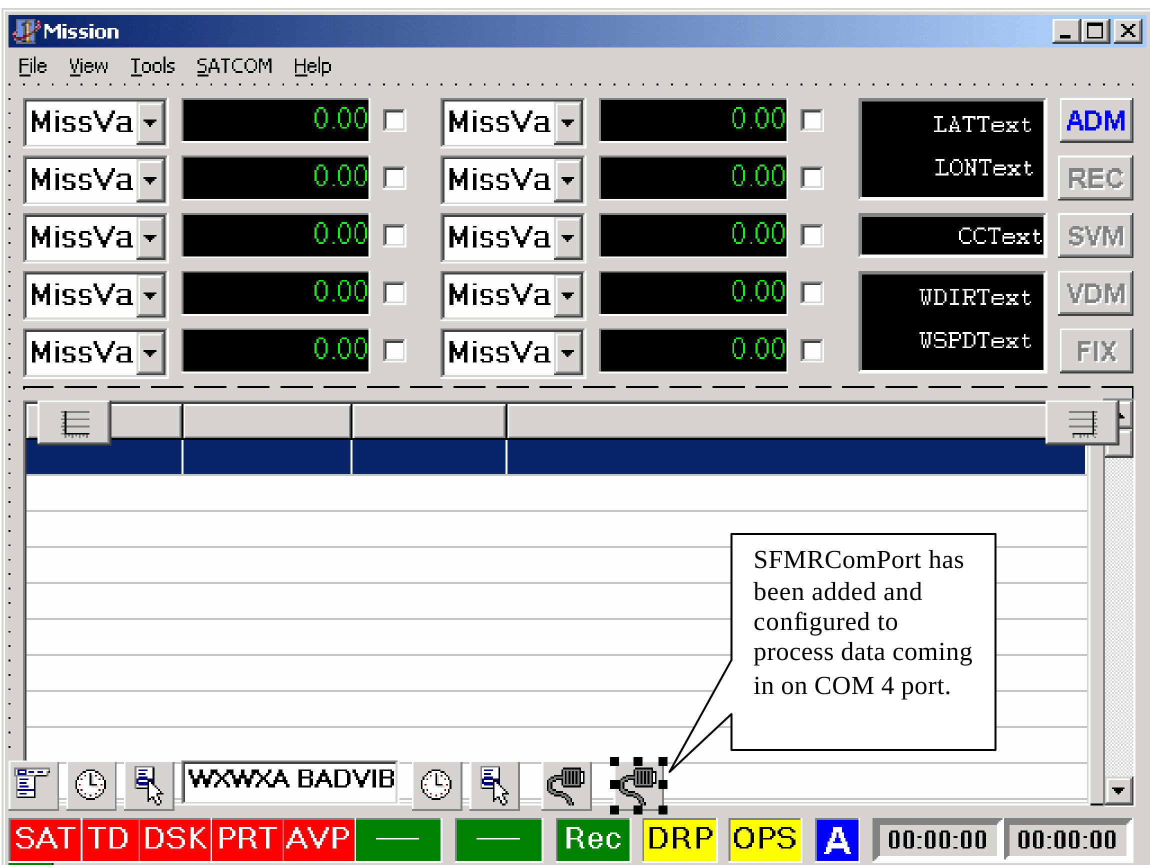


Figure 12 – ARWO Mission Manager Main Form(Design View)

This SFMRComPort added in the ARWO Mission Manager application was configured to receive data at 9600 baud, with 1 stop bit, and no parity. The SFMRComPort was setup to only process the data coming into the port based upon the receipt of a trigger. The SFMR simulation software was configured to output an uppercase N as the trigger/message delimiter. An event handler procedure (SFMRDataReceived) was added to the ARWO Mission Manager application that is called any time the trigger/message delimiter is received on COM port 4.

This event handler, SFMRDataReceived, would process the COM 4 port buffer and check the received size of the message. If the received message size was the expected size and the message had the message delimiter (i.e., an end of message marker), then the data in the message would be parsed. The data parsed from the received message would be written into the added SFMRShared data structure. In addition, the validity and source of the data would be determined based upon evaluating flags within the data stream, and the health of the SFMR sensor subsystem would be determined. The SFMRShared data structure added to the Mission Manager application is a record structure of TSFMRBuffer type listed below.

```
//
//  SFMR Sensor Interface
//
  TSFMRBuffer = Record
    SFMRTime      : single;      //SFMR Time Value
    SFMRSurfWS    : single;      //SFMR Surface Wind Speed
    SFMRRainRate  : single;      //SFMR Rain Fall Rate
    SFMRRMSError  : single;      //SFR RMS Error
    SFMRNumofCh   : single;      //SFMR Number of Channels Processed (6 Max)
    SFMRValidity  : single;      //SFMR Pitch/roll validity indicator
    SFMRBrghtTemp : array [0..5] of single; //SFMR Brightness Temperatures per Channel
    SFMRGains     : array [0..5] of single; //SFMR measured Gain for each Channel
    SFMROffset    : array [0..5] of single; //SFMR measured Offsets for each Channel
    SFMRTemps     : array [0..5] of single; //SFMR Thermistor readings per Channel
    SFMRHealth    : byte;        //Health Status of SFMR Sensor Device
    SFMRValid     : boolean;     //SFMR Validity for RR and SWS
    SFMRSource    : BusSource;   //Flag to Indicate whether SFMR Data Processed or Not
  end;
```

The setup of the COM 4 port was based upon processing variables contained within the arwo.ini file. The arwo.ini file was modified to contain additional variables that defined operational parameters for the processing of SFMR data. The System ([System]) segment of the arwo.ini file was modified to contain a flag that identified whether the COM 4 port should be configured to process actual SFMR sensor data, or whether the SFMR data should just be simulated in lieu of processing actual data from a SFMR sensor subsystem. This simulation operation is a baseline feature for all data acquisition I/O paths. This simulation feature is used for testing purposes and enables an operator to receive training on the operations of the ARWO software in a desktop office environment. The modification of the System segment of the arwo.ini file is listed below.

```
; ARWO Software Configuration Information
;
[System]
```

SimAD=0
Sim1553=0
SimSATCOM=0
SimAVAPS=0
SimSFMR=0

A new segment was also added to the arwo.ini file to define both the COM port to be used for SFMR data processing, and the baud rate for which to configure the port. The additional SFMR segment added to the arwo.ini file is listed below.

*; **SFMR Configuration***
;
[SFMR]
SFMRBaud=9600
SFMRCom=4

3.4.2 ARWO Software Mission Data Set Modifications

The primary 28 mission variable set processed and computed by the ARWO Mission Manager application was modified to contain the two additional variables from the SFMR sensor subsystem. These two additional variables are the Rainfall Rate (RR) and Surface Wind Speed (SWS). A set of arrays defined within TypePackage.pas were modified to contain these two additional variables, as well as define the units for these variables, the abbreviation for these two variables and so forth. The following Variable (VAR) arrays were modified to integrate the data received from the SFMR sensor subsystem into the ARWO software mission data set.

```
//Official readable name for each variable
VARNAME : array [0..MAXVARINDEX] of string = (
        'Angle of Attack',      'Baroset Pressure',      'Calib. Airspeed',
        'Course Correction',    'Corr. Static Press.',   'Dyn. Pressure',
        'D-Value',              'Geopotential Alt.',     'GPS Altitude',
        'Ground Speed',         'Height Std. Surface',   'Latitude',
        'Longitude',            'Press. Altitude',       'Pitch Angle',
        'Radar Altitude',       'Roll Angle',            'Rain Fall Rate',
        'Sea Level Pressure',   'Sideslip',              'Surface Wind Speed',
        'Static Air Temp',      'True Airspeed',         'Dew Point Temp',
        'True Heading',         'Track',                 'Total Temp',
        'Vertical Velocity',    'Wind Direction',        'Wind Speed');
```

The baseline variable set processed by ARWO Mission Manager was expanded to 30 variables. The VARNAME array listed above lists the full name for each mission variable. The following VAR array identifies the abbreviation to be used for each mission variable.

```
VARABBREV : array [0..MAXVARINDEX] of string = (
        'AOA',     'BSP',     'CAS',
        'CC',      'CSP',     'DPR',
        'DVAL',    'GA',      'GPSA',
        'GS',      'HSS',     'LAT',
        'LON',     'PA',      'PITCH',
```

'RA',	*'ROLL',*	***'RR',***
'SLP',	*'SS',*	***'SWS',***
'TA',	*'TAS',*	*'TD',*
'THD',	*'TRK',*	*'TT',*
'V V',	*'WD',*	*'WS');*

Each of these VAR arrays is enumerated in alphabetical order. The order of each of these VAR arrays is highly important, as the elements of the array are index throughout the ARWO Mission Manager software from low VAR ID to high VAR ID. In addition to these VAR arrays, the VAR arrays that define the minimum value, maximum value and default value for each mission variable were modified to contain a minimum, maximum and default value for RR and SWS. The minimum value, maximum value, default value, and primary/secondary engineering units for RR and SWS mission variables are listed in Table 7 below:

Table 7 – SFMR VAR Array Modifications

Mission Variable	Minimum	Maximum	Default	Primary Units	Secondary Units
RR	0	60	0	mm/hr	mm/hr
SWS	0	300	0	kts	m/sec

The full 30 mission variables along with the 10 extended data set variables are contained on the Mission Data Set Form. The Mission Data Set form was modified to contain the addition of the RR and SWS variables to the standard mission variable set. The modified Mission Data Set form is illustrated at run-time in Figure 13 below.

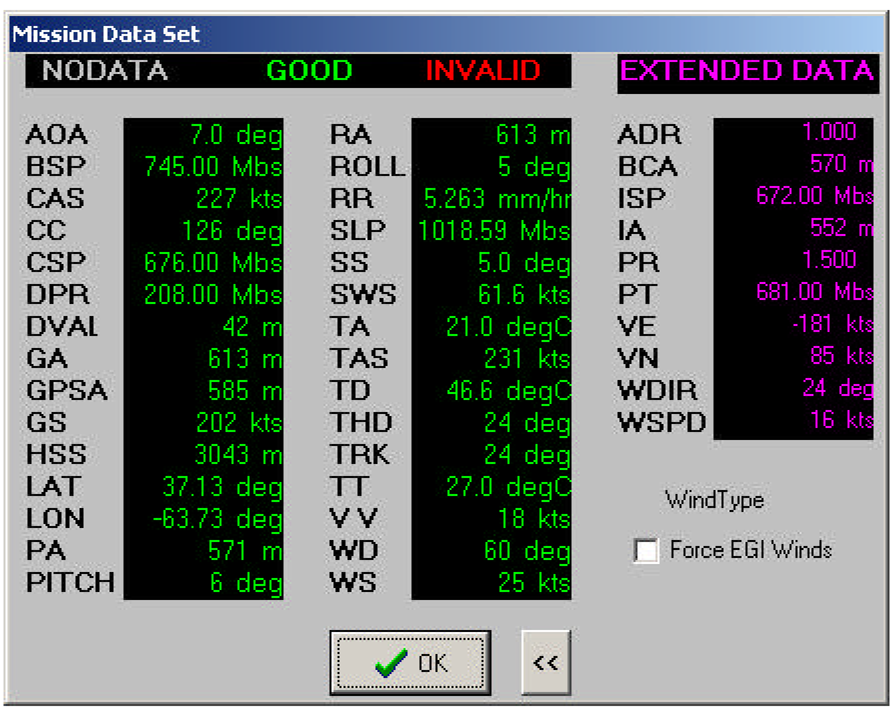


Figure 13 – ARWO Mission Manager Mission Data Set Form (Run-Time View)

All the same processing is performed on the RR and SWS variables, as is performed for the other 28 base-line mission variables. In essence, if the RR or SWS variable was not being received each second over COM port 4, the color for the value would change from Green to a Gray color. If the value for RR or SWS has been received for that 1 second, but the value was considered invalid either because the SFMR sensor subsystem identified it as invalid, or the value was out of range as checked by ARWO Mission Manager, then the color for the value would change to Red. These colors just described apply to the Mission Data Set form depicted in Figure 5 above.

In addition, to viewing the additional RR and SWS mission variables on the Mission Data Set form, these variables can be accessed and displayed in a combo box on the main form of the Mission Manager application. The RR and SWS variables were added to the standard VarDisplay array, which enables these variables to be plotted on the strip chart, to be viewed in any of the 10 combo boxes on the main form, or be displayed as part of the mission variable set on the bottom of the Graph Manager main form. A run-time view of the Mission Manager main form is illustrated in Figure 14 below, with RR and SWS being displayed in some of the 10 combo boxes.

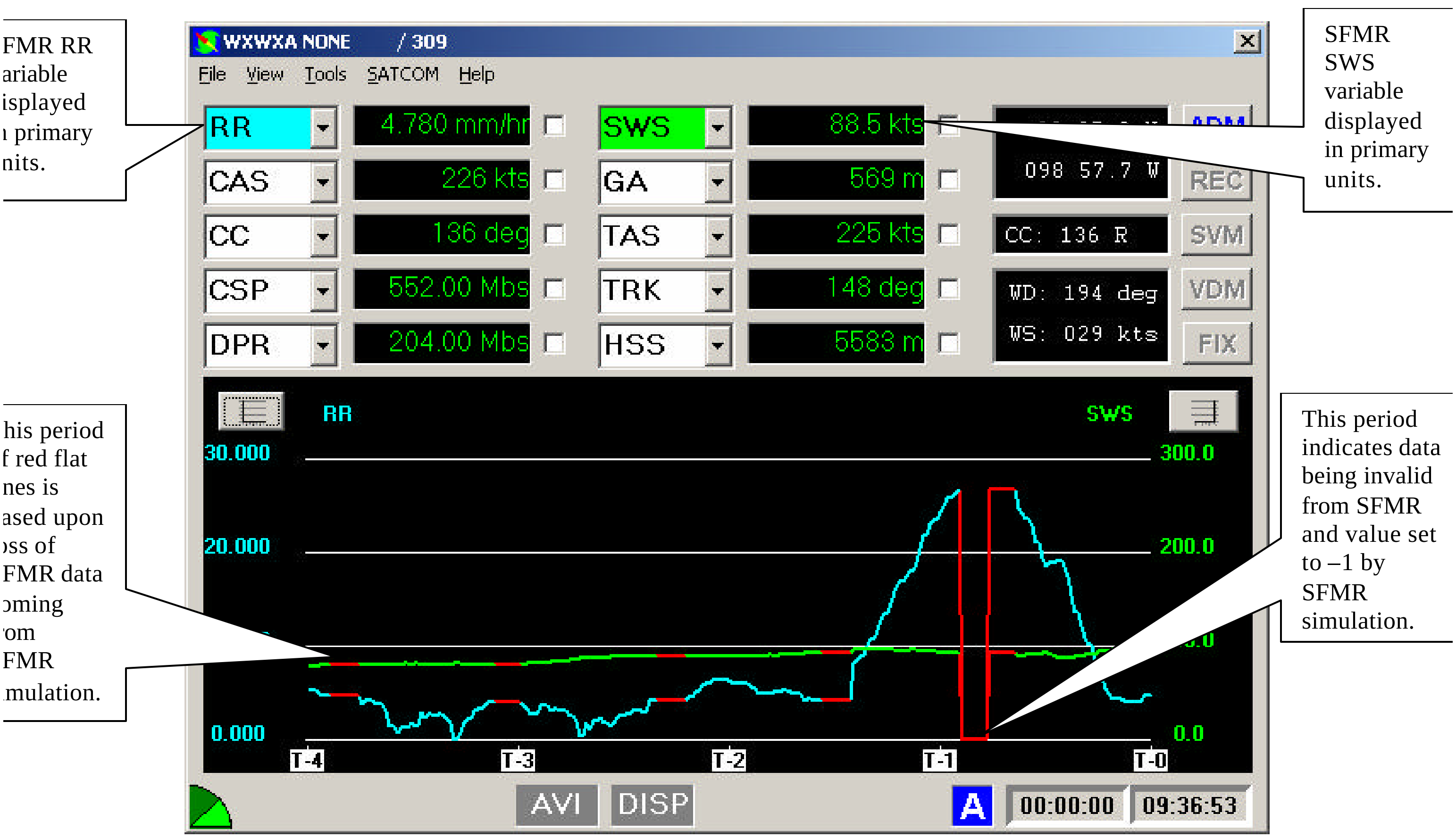
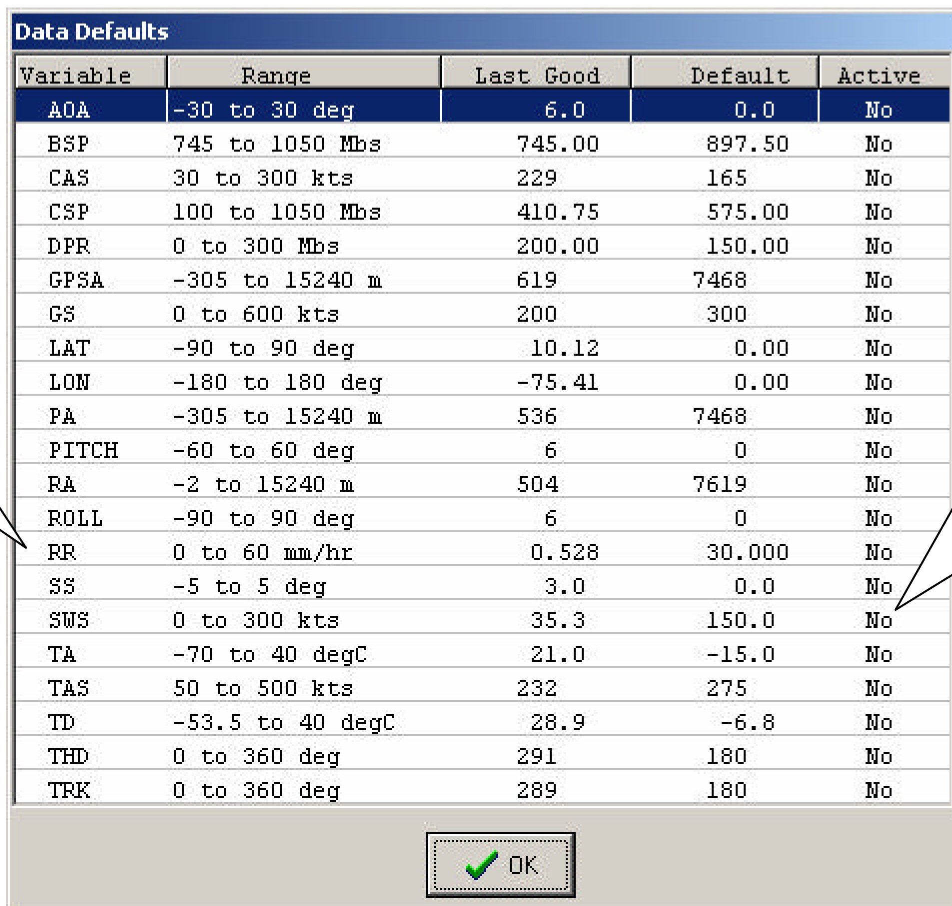


Figure 14 – ARWO Mission Manager Main Form (Run-Time View)

Figure 6 above, illustrates the added mission variables (RR and SWS) being processed from the SFMR sensor subsystem as being displayed in the combo boxes, as well as being plotted on the two-channel strip chart built into the ARWO Mission Manager application. All baseline functionality applies to these added mission variables (RR and SWS), as with the other 28 baseline mission variables. What that means, is that these variables can be frozen and unfrozen, their colors could change from Green, Cyan, Red and Yellow, and they can be plotted on the two-channel strip chart. Hence, the RR and SWS variables will be displayed/plotted in Green on the main form (i.e., combo box and strip chart) if the data is received and considered valid. The data value will be displayed in Cyan, if the operator has frozen the data value. The data value will be displayed in Red, if the data value has been received and the data value is considered invalid. The data value will be displayed in Yellow, if either the operator selects a default value for the variable, or there is no new value being received on COM port 4 for the SFMR based mission variable.

The ARWO Software Mission Manager Data Defaults form was also modified to support the addition of the RR and SWS variables to the baseline mission data set. The Data Defaults form enables the operator to set a default value for an acquired mission variable. The modified ARWO Mission Manager Data Defaults form is depicted in Figure 15 below.

RR Variable has been added to Data Defaults Form. The range is set in the VAR Arrays. Operator could set a default value using this form.



Data Defaults

Variable	Range	Last Good	Default	Active
AOA	-30 to 30 deg	6.0	0.0	No
BSP	745 to 1050 Mbs	745.00	897.50	No
CAS	30 to 300 kts	229	165	No
CSP	100 to 1050 Mbs	410.75	575.00	No
DPR	0 to 300 Mbs	200.00	150.00	No
GPSA	-305 to 15240 m	619	7468	No
GS	0 to 600 kts	200	300	No
LAT	-90 to 90 deg	10.12	0.00	No
LON	-180 to 180 deg	-75.41	0.00	No
PA	-305 to 15240 m	536	7468	No
PITCH	-60 to 60 deg	6	0	No
RA	-2 to 15240 m	504	7619	No
ROLL	-90 to 90 deg	6	0	No
RR	0 to 60 mm/hr	0.528	30.000	No
SS	-5 to 5 deg	3.0	0.0	No
SWS	0 to 300 kts	35.3	150.0	No
TA	-70 to 40 degC	21.0	-15.0	No
TAS	50 to 500 kts	232	275	No
TD	-53.5 to 40 degC	28.9	-6.8	No
THD	0 to 360 deg	291	180	No
TRK	0 to 360 deg	289	180	No

SWS Variable has been added to Data Defaults Form. The range is set in the VAR Arrays. Operator could set a default value using this form.

Figure 15 – ARWO Mission Manager Data Defaults Form (Run-Time View)

The operator can select to set a default value for either RR and SWS variables in the same way as all other baseline acquired mission variables. In addition, to setting a value, the operator selects to have this default value become Active. Setting the value active overrides the acquired value from a display purpose, as well as set the value for the mission variable that is recorded in the mission data files 1 and 10-second binary files.

3.4.3 ARWO Software Mission Recording Set Modifications

The ARWO software Mission Manager application was modified to expand the baseline VarDisplay and VarData arrays. The VarDisplay and VarData array contains the set of values for all variables that are a part of the VAR ID set (i.e., from AOA to WS). The VarDisplay array is accessed for displaying a mission variable value on the main form, which was illustrated in Figure 6 previously. The VarData array is accessed for recording a value for each mission variable (i.e., 28 baseline mission variables, plus RR and SWS).

The ReadSharedInterface procedure was modified to process the acquired RR and SWS mission variables from the added SFMRShared data structure (i.e., identified in section 2.4.1). In addition, the ReadSharedInterface procedure was modified to process and use the validity and source indications within the SFMRShared data structure. The contents of the VarData array are directly accessed by the SaveMissionData procedure within the InternalStorage unit for the recording of mission variables into the 1 and 10-second binary mission files. Hence, this modification to integrate the ARWO software with the SFMR sensor subsystem modified the baseline 1 and 10-second binary file structure. This modification to these recorded 1 and 10-second binary files requires a re-building of the ARWO Graph Manager to be compatible with this modified file structure. The following code excerpt outlines the modifications made to the recorded 1 and 10-second binary files.

```
THeaderRecord = Record
  Major     : smallint;                    // 2
  Minor     : smallint;                    // 2
  Release   : smallint;                    // 2
  Build     : smallint;                    // 2
  FileID    : smallint;                    // 2
  TailNumber: array [1..3] of char;        // 3
  Filler    : array [1..175] of char;      //175
end;

TOneSecondData = Record
  TimeStamp: TDateTime;                                   //  8
  Data     : array [low(VarID)..high(VarID)] of single;    //120
  Valid    : array [low(VarID)..high(VarID)] of boolean;   // 30
  Source   : array [low(VarID)..high(VarID)] of BusSource; // 30
end;
```

The TOneSecondData Record structure was expanded from a size of 176 bytes to 188 bytes. The addition of RR and SWS to the Data array increased the Data segment of the recorded data from 112 bytes to 120 bytes. The addition of RR and SWS to the Valid array increased the Valid segment from 28 bytes to 30 bytes. Likewise, the addition of RR and SWS to the Source array increased the Source segment from 28 bytes to 30 bytes. The THeaderRecord was also modified to increase the Filler array segment (i.e., from 163 bytes to 175 bytes) to have both the HeaderRecord and all OneSecondData records the same size of 188 bytes. There is a 4-byte value (i.e., single) that is recorded for each of the 30 mission variables, hence the overall total of 120 bytes for the Data array segment of the OneSecondData record. There is a 1-byte value (i.e., Boolean and BusSource) that is recorded for the validity flag and source tag for each of the 30 mission variables, hence 30 bytes each for both Valid array segment and Source array segment.

Figure 16 below depicts the exported contents of the 10-second binary file into an ASCII format. The time stamp and the first 16 mission variables (i.e., from AOA up to RA) are shown in Figure 16, with the remaining variables and validity and source tags shown in Figure 17.

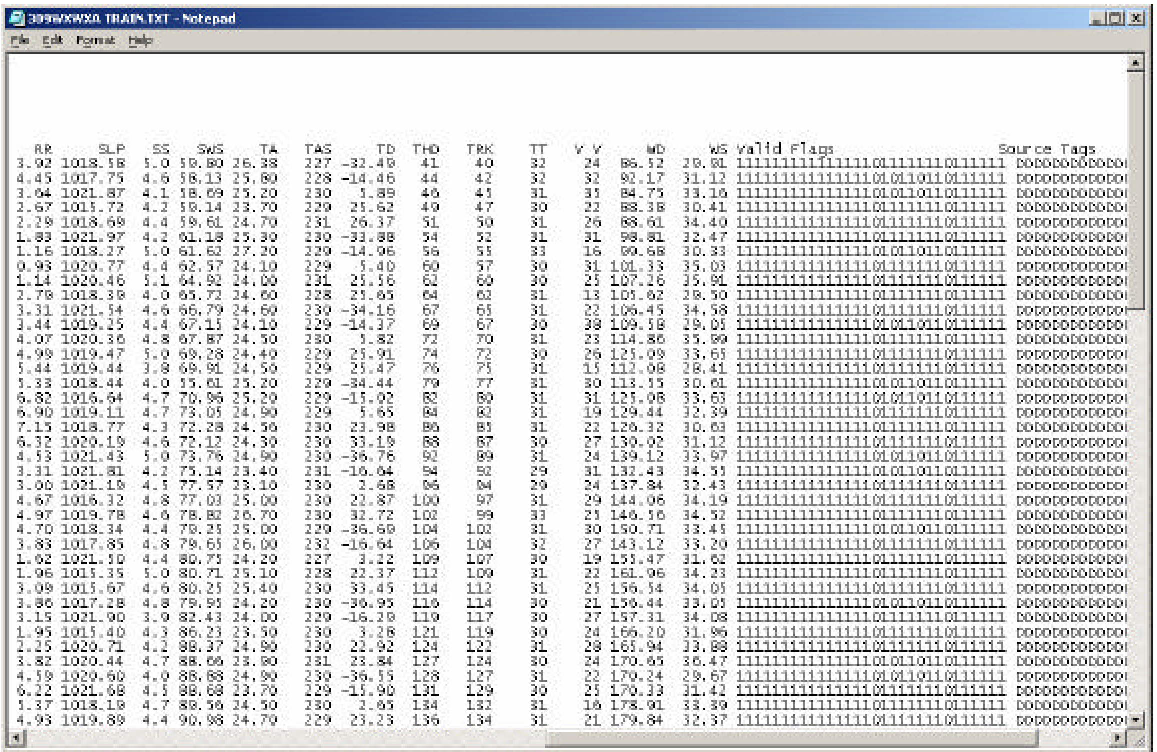
309WXWXA TRAIN.TXT - Notepad

File Edit Format Help

Export of 10 second data for WXWXA TRAIN at 14:43:57 on 20020121
WXWXA TRAIN created at 14:23 on 01/21/2002
software version : 15.400.21.0
File version : 1
Tail Number : 309

GMT Time	AOA	BSP	CAS	CC	CSP	DPR	DVAL	GA	GPSA	GS	HSS	LAT	LON	PA	PITCH	RA
14:24:00	9	745.00	228	136	660.13	203.25	40.77	579	632.38	206	3038.92	41.856	-66.679	538.00	5	578.63
14:24:10	9	745.00	231	140	657.88	203.00	33.37	583	588.40	205	3028.78	42.383	-67.137	550.00	5	583.20
14:24:20	8	745.00	231	130	655.38	204.90	67.61	608	597.80	204	3064.18	43.018	-67.735	540.50	5	607.90
14:24:30	9	745.00	229	132	652.88	203.90	19.84	581	598.00	205	3029.13	43.627	-68.360	561.60	4	581.20
14:24:40	8	745.00	229	129	650.38	203.20	46.97	581	628.30	203	3065.96	44.208	-69.011	534.30	5	581.00
14:24:50	7	745.00	229	136	647.88	204.20	65.51	603	587.30	206	3051.08	44.760	-69.687	537.70	4	602.90
14:25:00	9	745.00	228	135	645.38	203.70	39.23	587	625.30	206	3041.98	45.282	-70.386	547.80	4	586.70
14:25:10	8	745.00	230	134	642.88	205.40	55.07	609	612.00	203	3039.40	45.773	-71.107	554.40	4	609.10
14:25:20	9	745.00	229	138	640.38	204.00	58.89	599	587.60	204	3064.30	46.233	-71.849	539.80	5	598.30
14:25:30	10	745.00	229	134	637.88	204.30	43.11	594	609.40	205	3055.96	46.659	-72.611	550.70	4	593.40
14:25:40	8	745.00	228	130	635.38	204.40	59.24	607	601.90	203	3036.32	47.052	-73.390	548.20	5	607.00
14:25:50	9	745.00	231	132	632.88	204.60	40.45	597	606.10	205	3015.28	47.410	-74.185	556.80	5	596.80
14:26:00	9	745.00	229	136	630.38	202.20	52.87	599	610.50	204	3039.20	47.733	-74.996	545.70	5	598.10
14:26:10	8	745.00	229	144	627.88	203.00	51.49	608	594.20	206	3059.71	48.021	-75.820	556.50	5	607.50
14:26:20	9	745.00	229	127	625.38	205.60	52.00	599	615.40	205	3061.84	48.273	-76.655	547.00	5	598.50
14:26:30	9	745.00	230	127	622.88	204.70	34.80	585	579.60	205	3013.25	48.487	-77.501	550.60	5	584.90
14:26:40	8	745.00	230	136	620.38	205.20	19.71	589	602.30	204	2999.97	48.665	-78.355	568.80	5	588.00
14:26:50	8	745.00	228	138	617.88	204.90	42.13	597	593.60	205	3026.69	48.805	-79.217	555.20	4	596.80
14:27:00	8	745.00	229	132	615.50	204.67	45.44	616	582.67	206	3051.81	48.908	-80.083	570.22	4	615.11
14:27:10	9	745.00	231	132	613.13	204.10	57.74	607	603.50	205	3066.47	48.968	-80.866	549.00	5	606.20
14:27:20	9	745.00	227	139	610.63	204.90	57.35	613	613.60	206	3029.98	48.998	-81.738	556.00	5	612.80
14:27:30	8	745.00	229	131	608.13	205.40	57.84	597	598.60	205	3017.74	48.991	-82.611	539.20	5	596.50
14:27:40	8	745.00	229	133	605.63	205.10	53.84	609	612.40	205	3018.94	48.945	-83.482	555.30	5	608.60
14:27:50	8	745.00	230	137	603.13	204.40	23.52	583	598.00	205	3023.94	48.861	-84.351	559.80	5	582.80
14:28:00	8	745.00	228	137	600.63	204.50	59.83	604	622.50	203	3008.88	48.740	-85.215	543.90	4	603.20
14:28:10	9	745.00	229	139	598.13	205.10	31.21	586	618.30	205	5518.90	48.581	-86.073	554.70	5	585.40
14:28:20	8	745.00	230	128	595.63	205.30	30.09	575	597.30	204	5535.08	48.385	-86.923	544.70	5	574.30
14:28:30	9	745.00	230	138	593.13	205.80	57.60	610	626.40	205	5552.31	48.151	-87.764	552.10	4	609.20
14:28:40	10	745.00	229	141	590.63	206.40	14.65	555	592.80	205	5582.04	47.882	-88.594	540.70	5	554.90
14:28:50	8	745.00	229	135	588.13	204.60	22.24	570	589.90	204	5634.09	47.576	-89.411	548.00	4	569.80
14:29:00	8	745.00	229	134	585.63	207.10	20.42	570	609.80	204	5483.20	47.235	-90.214	549.30	5	569.30
14:29:10	8	745.00	230	131	583.13	204.70	57.92	599	620.20	204	5523.38	46.860	-91.002	540.80	5	598.30
14:29:20	7	745.00	229	136	580.63	204.10	6.18	563	611.40	206	5484.73	46.450	-91.772	556.80	5	562.60
14:29:30	9	745.00	230	134	578.13	203.80	58.27	593	561.80	203	5615.30	46.007	-92.524	534.30	5	592.20
14:29:40	10	745.00	229	136	575.82	204.40	55.55	614	595.60	204	5613.14	45.532	-93.256	558.50	4	613.70
14:29:50	10	745.00	228	133	573.13	204.60	48.12	600	589.10	206	5519.31	45.025	-93.966	551.90	4	599.70
14:30:00	9	745.00	230	130	570.63	201.70	55.50	614	591.10	204	5516.46	44.488	-94.654	559.70	4	613.90
14:30:10	9	745.00	229	136	568.13	204.80	29.95	576	592.10	205	5513.22	43.921	-95.318	548.10	5	575.80
14:30:20	8	745.00	230	137	565.63	205.40	50.13	607	591.20	205	5598.58	43.326	-95.956	556.70	5	606.60

Figure 16 – ARWO Mission Manager – Exported 10 Second Data File (1rst Half)



RR	SLP	SS	SWS	TA	TAS	TD	THD	TRK	TT	V V	WD	WS	Valid Flags	Source Tags
3.92	1018.58	5.0	59.80	26.38	227	-32.49	41	40	32	24	86.52	29.91	111111111111111011111110111111	DDDDDDDDDDDD
4.45	1017.75	4.6	58.13	25.80	228	-14.46	44	42	32	32	92.17	31.12	111111111111111010110110111111	DDDDDDDDDDDD
3.64	1021.87	4.1	58.69	25.20	230	5.89	46	45	31	35	84.75	33.16	111111111111111010110110111111	DDDDDDDDDDDD
2.67	1015.72	4.2	59.14	23.70	229	25.62	49	47	30	22	88.38	30.41	111111111111111011111110111111	DDDDDDDDDDDD
2.29	1018.69	4.4	59.61	24.70	231	26.37	51	50	31	26	88.61	34.40	111111111111111011111110111111	DDDDDDDDDDDD
1.83	1021.97	4.2	61.18	25.30	230	-33.88	54	52	31	31	98.81	32.47	111111111111111011111110111111	DDDDDDDDDDDD
1.16	1018.27	5.0	61.62	27.20	229	-14.96	56	55	33	16	99.68	30.33	111111111111111010110110111111	DDDDDDDDDDDD
0.93	1020.77	4.4	62.57	24.10	229	5.40	60	57	30	31	101.33	35.03	111111111111111011111110111111	DDDDDDDDDDDD
1.14	1020.46	5.1	64.92	24.00	231	25.56	62	60	30	25	107.26	35.91	111111111111111011111110111111	DDDDDDDDDDDD
2.78	1018.39	4.0	65.72	24.60	228	25.65	64	62	31	13	105.62	29.50	111111111111111011111110111111	DDDDDDDDDDDD
3.31	1021.54	4.6	66.79	24.60	230	-34.16	67	65	31	22	106.45	34.58	111111111111111011111110111111	DDDDDDDDDDDD
3.44	1019.25	4.4	67.15	24.10	229	-14.37	69	67	30	38	109.58	29.05	111111111111111010110110111111	DDDDDDDDDDDD
4.07	1020.36	4.8	67.87	24.50	230	5.82	72	70	31	23	114.86	35.99	111111111111111011111110111111	DDDDDDDDDDDD
4.99	1019.47	5.0	69.28	24.40	229	25.91	74	72	30	26	125.09	33.65	111111111111111011111110111111	DDDDDDDDDDDD
5.44	1019.44	3.8	69.91	24.50	229	25.47	76	75	31	15	112.08	28.41	111111111111111011111110111111	DDDDDDDDDDDD
5.33	1018.44	4.0	55.61	25.20	229	-34.44	79	77	31	30	113.55	30.61	111111111111111010110110111111	DDDDDDDDDDDD
6.82	1016.64	4.7	70.96	25.20	229	-15.02	82	80	31	31	125.08	33.63	111111111111111010110110111111	DDDDDDDDDDDD
6.90	1019.11	4.7	73.05	24.90	229	5.65	84	82	31	19	129.44	32.39	111111111111111011111110111111	DDDDDDDDDDDD
7.15	1018.77	4.3	72.28	24.56	230	23.98	86	85	31	22	126.32	30.63	111111111111111011111110111111	DDDDDDDDDDDD
6.32	1020.19	4.6	72.12	24.30	230	33.19	88	87	30	27	130.02	31.12	111111111111111011111110111111	DDDDDDDDDDDD
4.53	1021.43	5.0	73.76	24.90	230	-36.76	92	89	31	24	139.12	33.97	111111111111111010110110111111	DDDDDDDDDDDD
3.31	1021.81	4.2	75.14	23.40	231	-16.04	94	92	29	31	132.43	34.55	111111111111111010110110111111	DDDDDDDDDDDD
3.00	1021.10	4.5	77.57	23.10	230	2.68	96	94	29	24	137.84	32.43	111111111111111011111110111111	DDDDDDDDDDDD
4.67	1016.32	4.8	77.03	25.00	230	22.87	100	97	31	29	144.06	34.19	111111111111111011111110111111	DDDDDDDDDDDD
4.97	1019.78	4.6	78.82	26.70	230	32.72	102	99	33	25	146.56	34.52	111111111111111011111110111111	DDDDDDDDDDDD
4.70	1018.34	4.4	79.25	25.00	229	-36.69	104	102	31	30	150.71	33.45	111111111111111010110110111111	DDDDDDDDDDDD
3.83	1017.85	4.8	79.65	26.00	232	-16.64	106	104	32	27	143.12	33.20	111111111111111011111110111111	DDDDDDDDDDDD
1.62	1021.50	4.4	80.75	24.29	227	3.22	109	107	30	19	155.47	31.62	111111111111111011111110111111	DDDDDDDDDDDD
1.96	1015.35	5.0	80.71	25.10	228	22.37	112	109	31	22	161.96	34.23	111111111111111011111110111111	DDDDDDDDDDDD
3.09	1015.67	4.6	80.25	25.40	230	33.45	114	112	31	25	156.54	34.05	111111111111111011111110111111	DDDDDDDDDDDD
3.86	1017.28	4.8	79.95	24.20	230	-36.95	116	114	30	21	156.44	33.05	111111111111111010110110111111	DDDDDDDDDDDD
3.15	1021.90	3.9	82.43	24.00	229	-16.29	119	117	30	27	157.31	34.08	111111111111111011111110111111	DDDDDDDDDDDD
1.95	1015.40	4.3	86.23	23.50	230	3.28	121	119	30	24	166.20	31.96	111111111111111011111110111111	DDDDDDDDDDDD
2.25	1020.71	4.2	88.37	24.90	230	22.92	124	122	31	28	165.94	33.88	111111111111111011111110111111	DDDDDDDDDDDD
3.82	1020.44	4.7	88.66	23.90	231	23.84	127	124	30	24	170.65	36.47	111111111111111010110110111111	DDDDDDDDDDDD
4.59	1020.60	4.0	88.88	24.90	230	-36.55	128	127	31	22	170.24	29.67	111111111111111010110110111111	DDDDDDDDDDDD
6.22	1021.68	4.5	88.68	23.70	229	-15.90	131	129	30	25	170.33	31.42	111111111111111011111110111111	DDDDDDDDDDDD
5.37	1018.10	4.7	89.56	24.50	230	2.65	134	132	31	16	178.91	33.39	111111111111111011111110111111	DDDDDDDDDDDD
4.93	1019.89	4.4	90.98	24.79	229	23.23	136	134	31	21	179.84	32.37	111111111111111011111110111111	DDDDDDDDDDDD

Figure 17 – ARWO Mission Manager – Exported 10 Second Data File (2nd Half)

3.4.4 ARWO Software System Health Modifications

The ARWO Software Mission Manager System Health form was modified to depict the status of the COM port connection with the SFMR sensor, and the status of the SFMR sensor itself. The status of receiving or not receiving data over the COM port from the SFMR is checked every 1-second period. The OneSecTimer procedure within the ARWO Mission Manager application was modified to perform the status check of whether data is being received or not. The COM port itself is only processed based upon receipt of the trigger, hence the COM port is not processed on any periodic timer, but rather is dependent on the interval at which the data is being received. However, the SFMR sensor subsystem is designed to output data at either a 1 or 2 Hz rate, and the SFMR simulation that was used to develop and test the modifications to the ARWO software was configured to output the data at a 1 Hz rate.

The ARWO software design was structured around the use of flags and counters to indicate whether data was being received over the COM port connected to the SFMR sensor or not. In the OneSecTimer procedure the code was modified to check the state of these flags and counter. Hence, during the OneSecTimer operation the state of the SFMR sensor and COM port was checked and set each second. If data was not being received, and yet the software was configured (i.e., based upon SimSFMR flag in arwo.ini file) to actively process data from the SFMR sensor then an indication would be generated and written to the System Event Log. If data were received that was larger than what was expected (i.e., in a condition of not being able to parse the data, but data was received), then this condition would also be annunciated within the System Event Log. Figure 18 below illustrates these indications within the System Event Log.

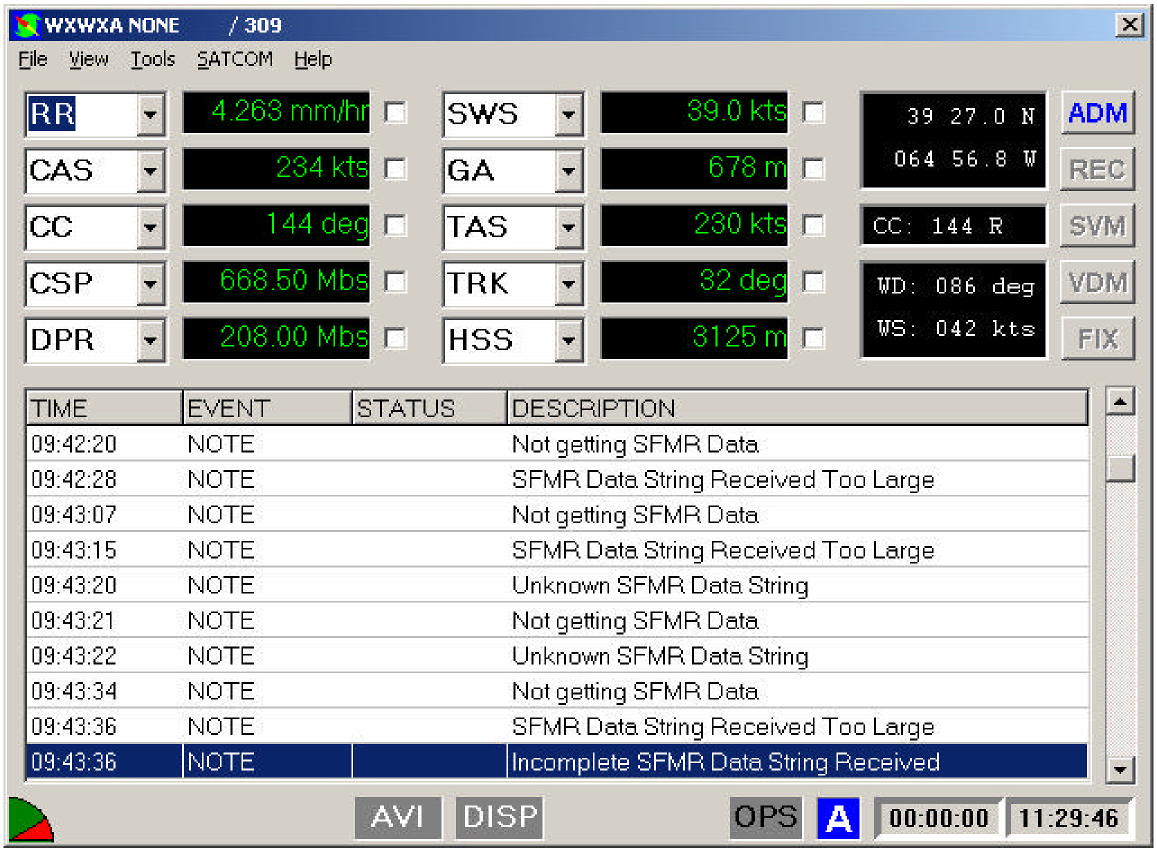


Figure 18 – ARWO Mission Manager – System Event Log (Run-Time View)

There was no graphical object added to the status bar along the bottom of the Mission Manager main form, as there was no room on the status bar for another object. There has been logic embedded within the ARWO Software Mission Manager application to identify the status of the SFMR data processing. Currently, indications of something not normal occur to the System Event Log. For actual production purposes these indications within the System Event Log would probably be eliminated or only be written to an Expanded System Event Log. In addition, for a production release of ARWO software extra real estate on the main form could be utilized to indicate the status of the SFMR data processing. The look up angle for the SATCOM satellite in use needs to be moved from the status bar. The design view of the ARWO Mission Manager main form could be altered as illustrated in Figure 19 below to depict the SFMR status and antenna angle look up.

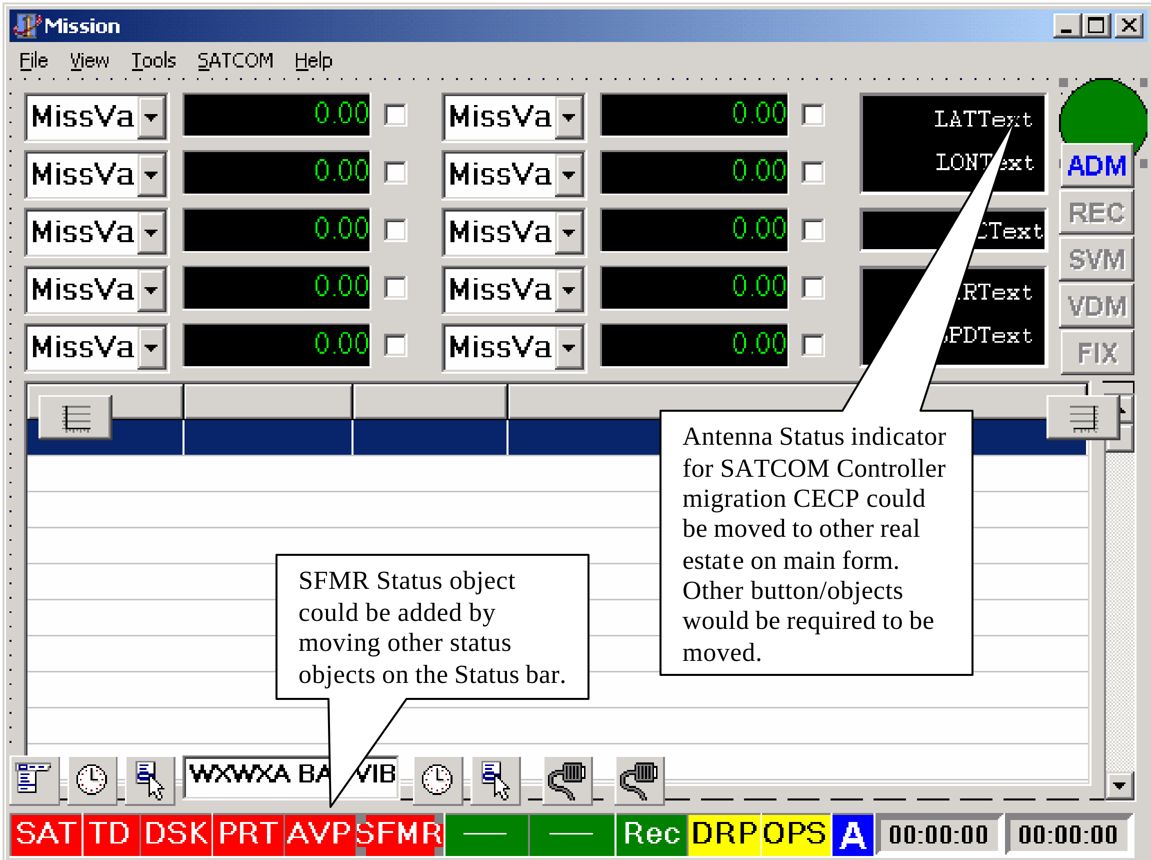


Figure 19 – ARWO Mission Manager – Alternative Main Form (Design View)

In addition, to the indications within the System Event Log depicted in Figure 18 related to the status of processing SFMR data, the System Health form was modified to show the status of the SFMR sensor and the serial COM port used to interface with the SFMR sensor. The modified System Health form is illustrated in Figure 20 below.

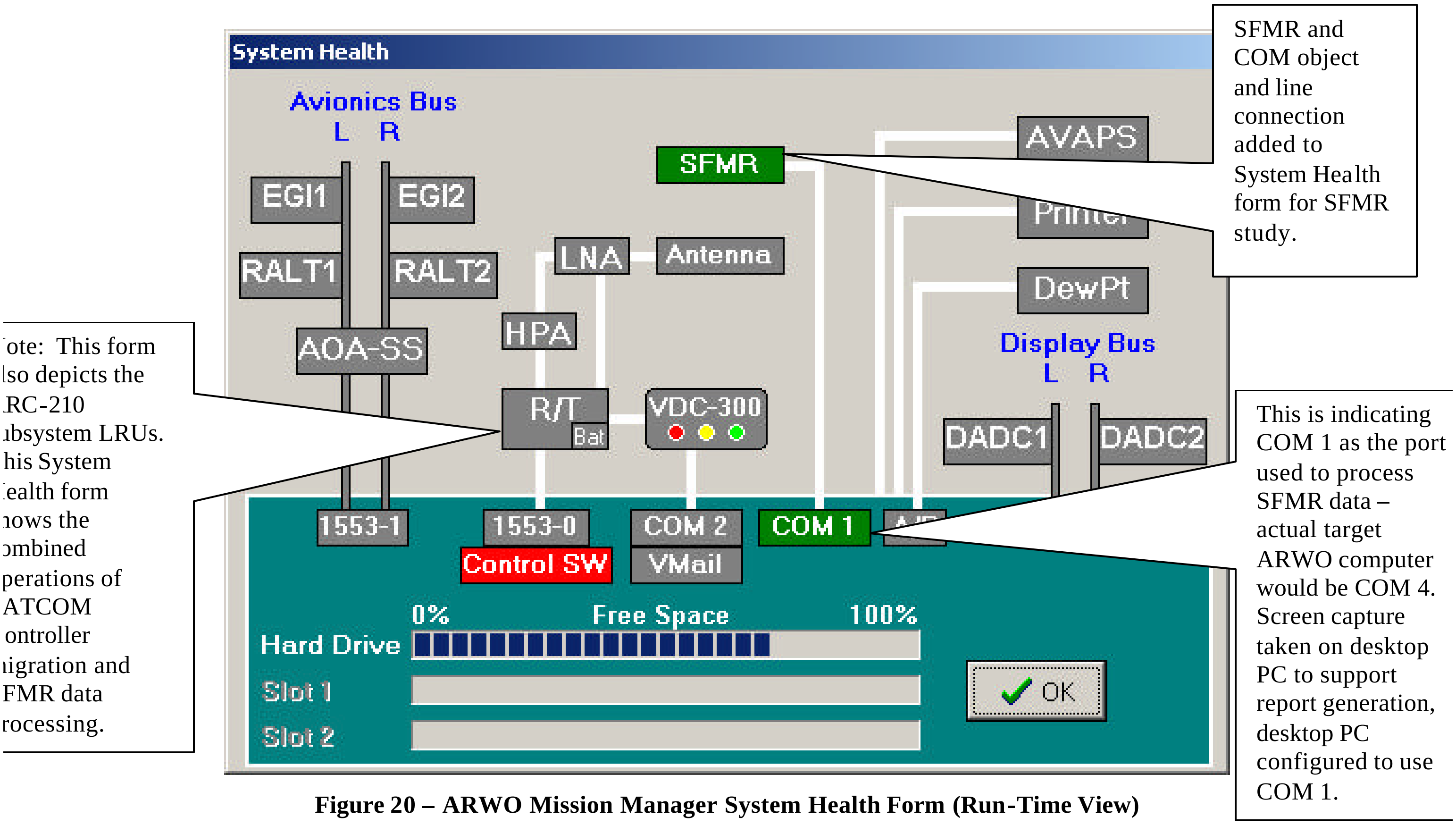


Figure 20 – ARWO Mission Manager System Health Form (Run-Time View)

The HealthSource unit of the ARWO Mission Manager application was modified to update the status of the SFMR object and COM port object added to the form. The status of both of these objects is updated 1/sec when the form is active (i.e., being viewed). The same color scheme applies to these objects (SFMR and COM) added for the SFMR integration study as with all other baseline objects on this System Health form. The SFMR object is colored Green if data is being received from the SFMR and the SFMR data received indicates that the SFMR sensor subsystem is fully operational. The SFMR object is colored Red if the data received from the SFMR sensor subsystem indicates bad status or a fault condition. The SFMR object is Gray if no data is being received from the SFMR sensor subsystem; hence the status of the SFMR is unknown.

The COM port object used to connect to the SFMR sensor subsystem is evaluated and status indicated on the System Health form as well. If there are any problems configuring the COM port for interfacing with the SFMR sensor subsystem, the COM port object would be colored Red. Otherwise, if the COM port has been configured properly with no error indications being received about the COM port object, the COM port object would be colored Green. If the COM port object is not being used, such as the ARWO software was internally simulating acquisition of the SFMR data (i.e., based upon the SimSFMR flag within the arwo.ini file), then the COM port object would be colored Gray.

3.4.5 ARWO Software RECCO Message Processing Modifications

The ARWO software Reconnaissance (i.e., listed as RECCO) message processing was modified to determine whether the FlightWind field of the RECCO message should be automatically set or not. This FlightWind field is also referred to as Group 4 data. If there is SWS data associated with the time of the

RECCO message, then the Wind Direction (WD) from either the computed Winds or the EGI winds are used in conjunction with the SWS received from the SFMR sensor. This data is formatted such that the Hundredths and Tenths digit of the WD variable (i.e., 2 digits) is written into the group 4 data along with the two most significant digits of the SWS variable (i.e., 2 digits being either Hundredths and Tenths, or Tenths and Ones digit). The run time view of the RECCO Message showing an automatic insertion of WD and SWS in the group 4 data is illustrated in Figure 21 below.

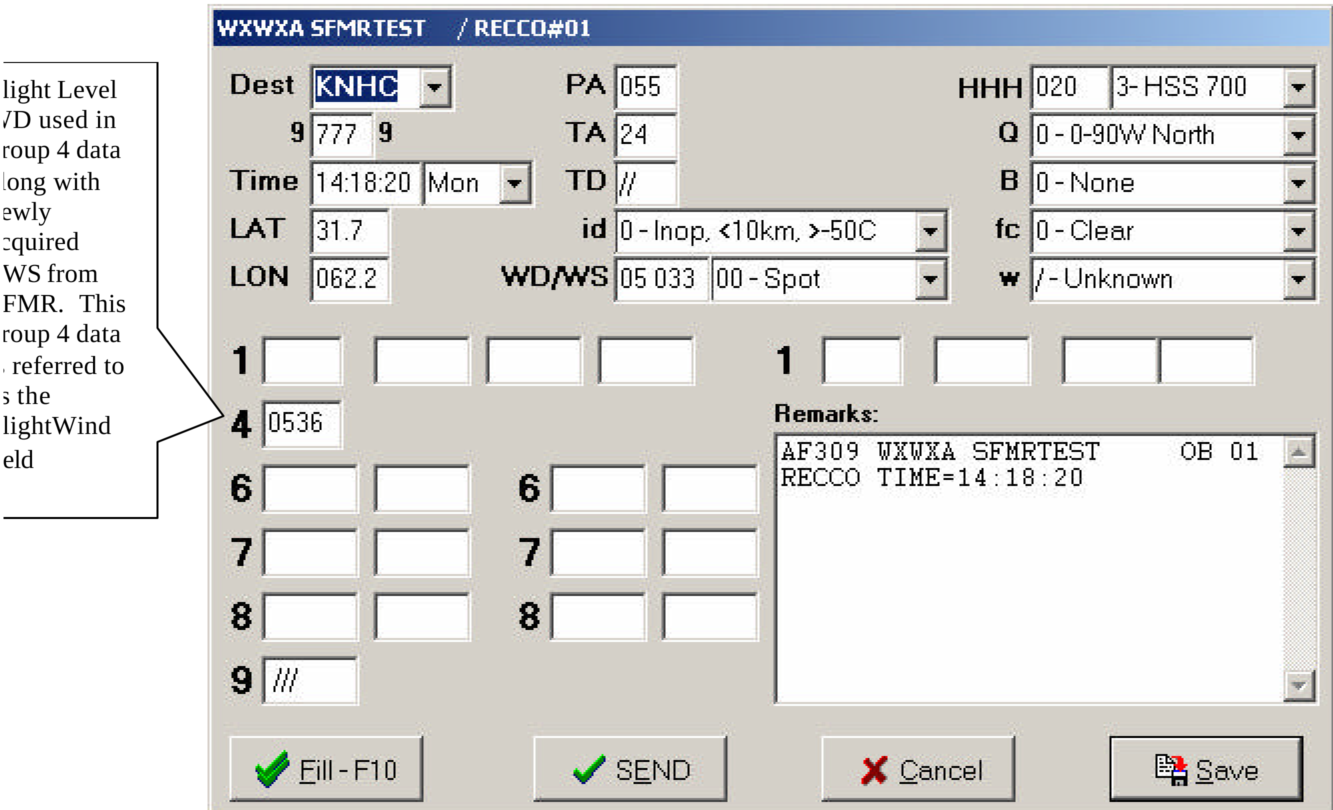


Figure 21 – ARWO Mission Manager RECCO Message Form (Run-Time View)

The fact that according to the National Hurricane Operations Plan (NHOP) the data in the group 4 data is limited to 2 digits each for wind direction and surface wind speed requires encoding of the value stored in the FlightWind field. The SFMR sensor subsystem does not provide surface wind direction; hence the computed flight level wind direction was used in the Group 4 data FlightWind field. The raw view of this same RECCO Message with the Group 4 data entry listed is illustrated in Figure 22 below.

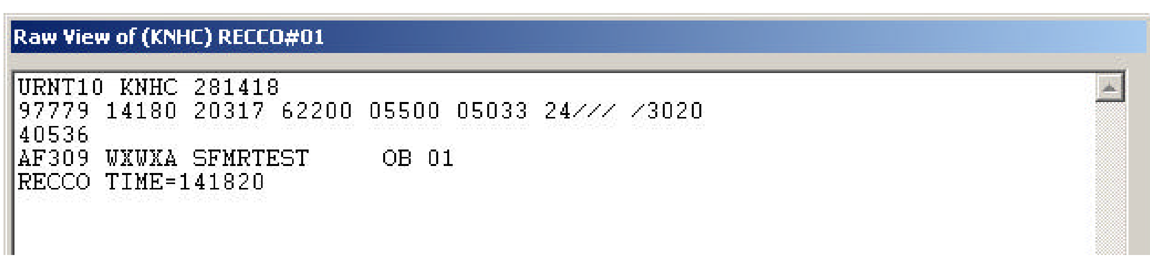


Figure 22 – ARWO Mission Manager RECCO Message (Raw Form View)

3.4.6 ARWO Software VORTEX Message Processing Modifications

The ARWO software VORTEX message processing was modified to automatically fill in the maximum surface wind speed field, and compute a bearing a range to this max surface wind speed on the inbound leg. This field in the baseline ARWO software functionality was an operator entry field exclusively; as there was no means to accurately determine the maximum surface wind speed. The LoadData procedure within VORTEXSource unit was modified to search from all the recorded 10 second data on the inbound leg to determine the maximum surface wind speed, and compute the bearing and range from the fix point out to this maximum surface wind speed. The VORTEX message form is illustrated in Figure 23 below depicting an automatically determined maximum surface wind speed, and bearing and range to this maximum surface wind speed.

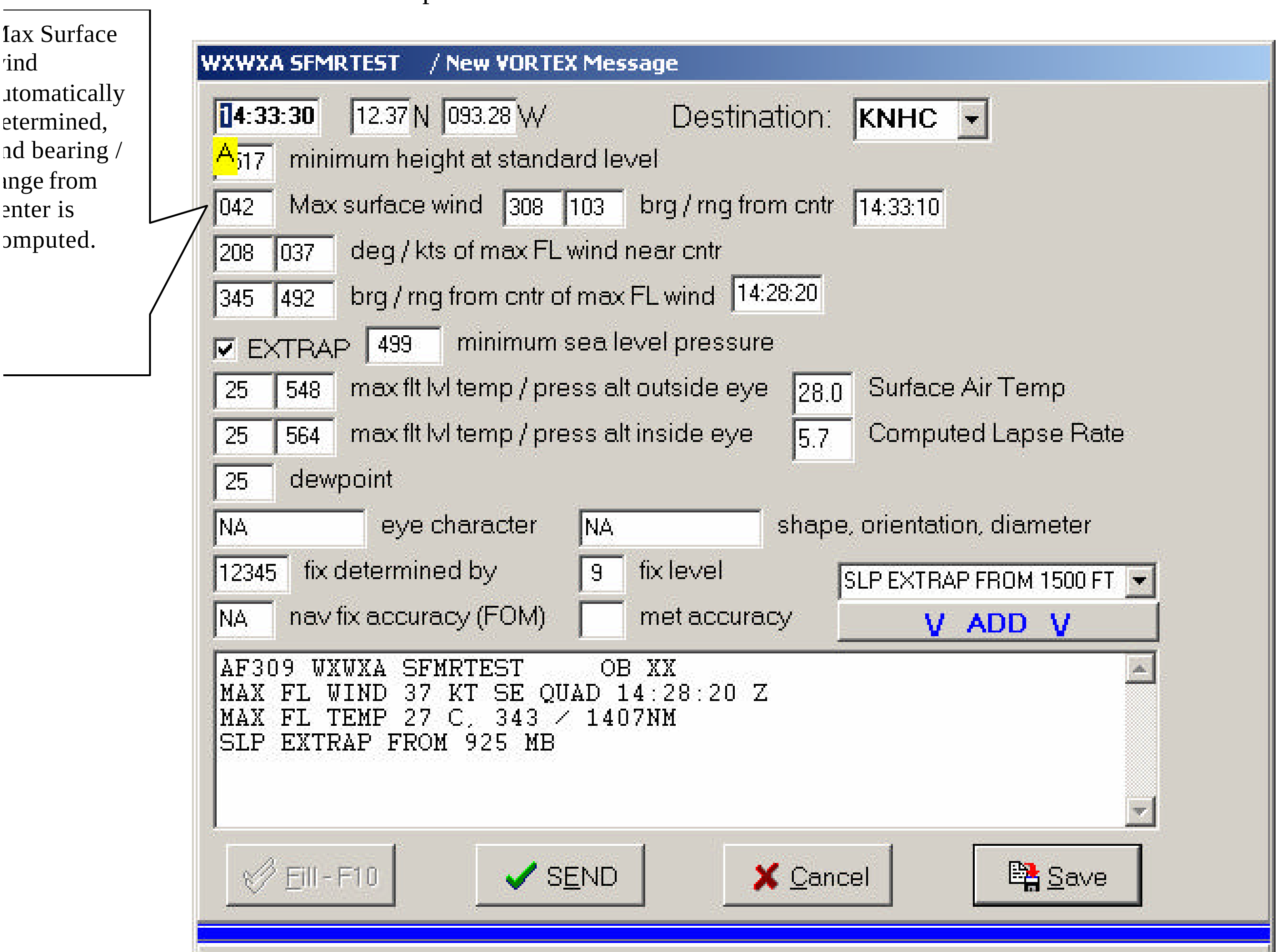
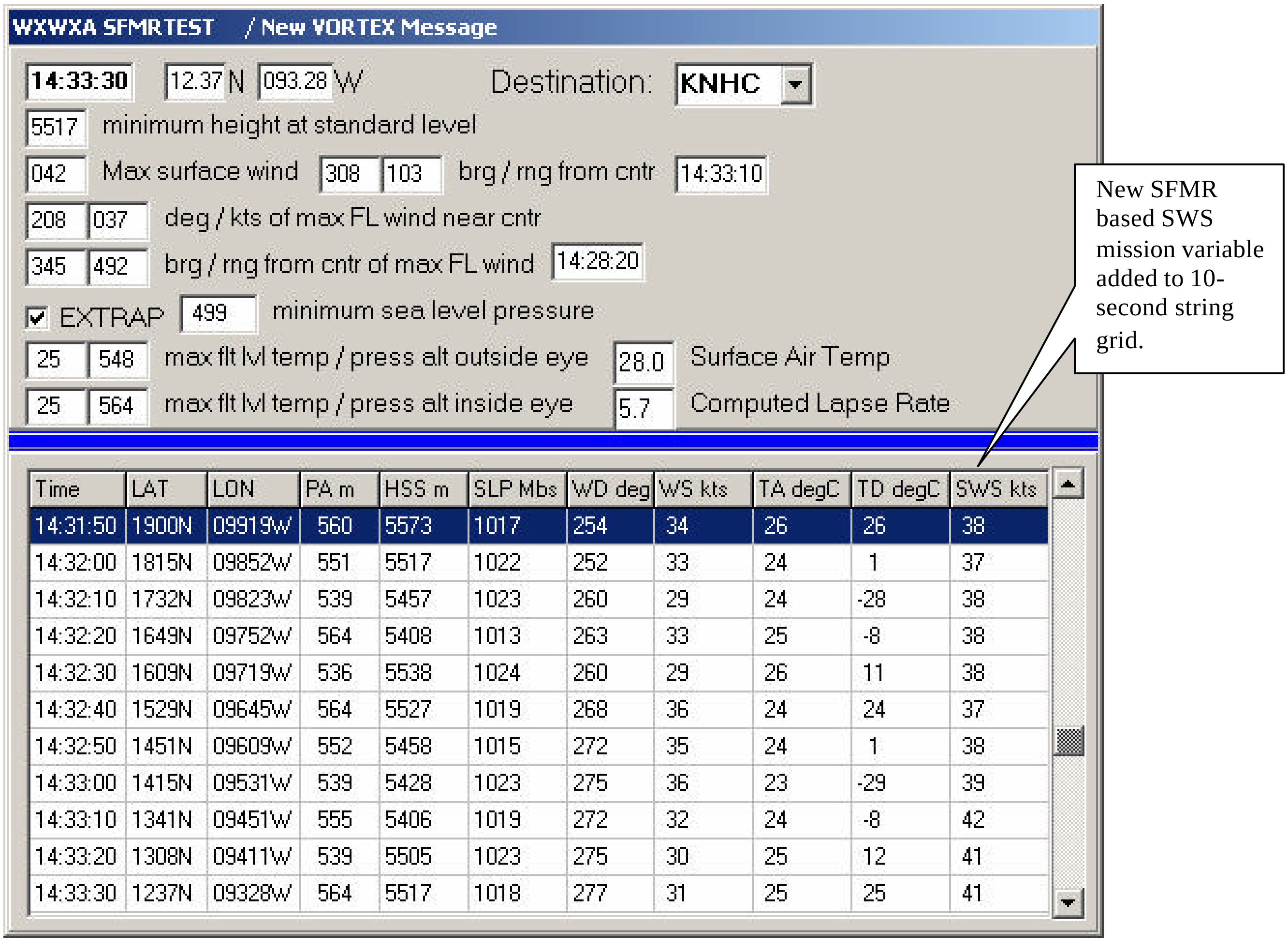


Figure 23 – ARWO Mission Manager VORTEX Message (Run-Time View)

In addition, to this change to the LoadData procedure to automatically determine maximum surface wind speed, and compute bearing and range from center, the form was expanded in size horizontally. The VORTEX Message form increase in width was to support the addition of the SWS variable to the 10-second grid of mission variables displayed below the splitter bar (i.e., appears as blue bar in VORTEX Message form illustrated in Figure 23 above). The addition of the SWS mission variable to the 10-second grid on the VORTEX Message form is illustrated in Figure 24 below.



Time	LAT	LON	PA m	HSS m	SLP Mbs	WD deg	WS kts	TA degC	TD degC	SWS kts
14:31:50	1900N	09919W	560	5573	1017	254	34	26	26	38
14:32:00	1815N	09852W	551	5517	1022	252	33	24	1	37
14:32:10	1732N	09823W	539	5457	1023	260	29	24	-28	38
14:32:20	1649N	09752W	564	5408	1013	263	33	25	-8	38
14:32:30	1609N	09719W	536	5538	1024	260	29	26	11	38
14:32:40	1529N	09645W	564	5527	1019	268	36	24	24	37
14:32:50	1451N	09609W	552	5458	1015	272	35	24	1	38
14:33:00	1415N	09531W	539	5428	1023	275	36	23	-29	39
14:33:10	1341N	09451W	555	5406	1019	272	32	24	-8	42
14:33:20	1308N	09411W	539	5505	1023	275	30	25	12	41
14:33:30	1237N	09328W	564	5517	1018	277	31	25	25	41

Figure 24 – ARWO Mission Manager VORTEX Message – 10 Second Data Grid

The TenSecGrid data structure was modified within the VORTEXSource unit to add the SWS mission variable. In addition, the TenSecScrollChange procedure was modified to search for the SWS variable within the 10-second binary data file when updating the modified TenSecGrid (i.e., string grid) contained below the splitter on the VORTEX message.

3.4.7 ARWO Software SUPVOR Message Processing Modifications

The ARWO software SUPVOR (i.e., stands for Supplementary VORTEX message) message processing was modified to automatically fill in the surface wind speed fields for both the Inbound and Outbound legs. This field in the baseline ARWO software functionality is contained on the form, however the operator must manually enter a value for these surface winds. The InboundFill and OutboundFill procedures contained within the SUPVORSource unit were modified under this study. Logic was added to these InboundFill and OutboundFill procedures to check the value of the new SWS mission variable within the recorded 10-second binary file. The InboundFill procedure determines the SWS value that occurred at the start of the Inbound leg (i.e., the time/point denoted by the RECCO taken at the start of the Inbound leg). The OutboundFill procedure was modified to determine the SWS value that occurred at the center of the hurricane, or the SWS associated with the VORTEX or Fix point. These determined surface wind speed values are then automatically filled into the Starting SFC Wind field for the Inbound leg, and the Center SFC Wind field for the Outbound leg. The SUPVOR message with the Starting SFC Wind and Center SFC Wind speed fields automatically filled is illustrated in Figure 25 below.

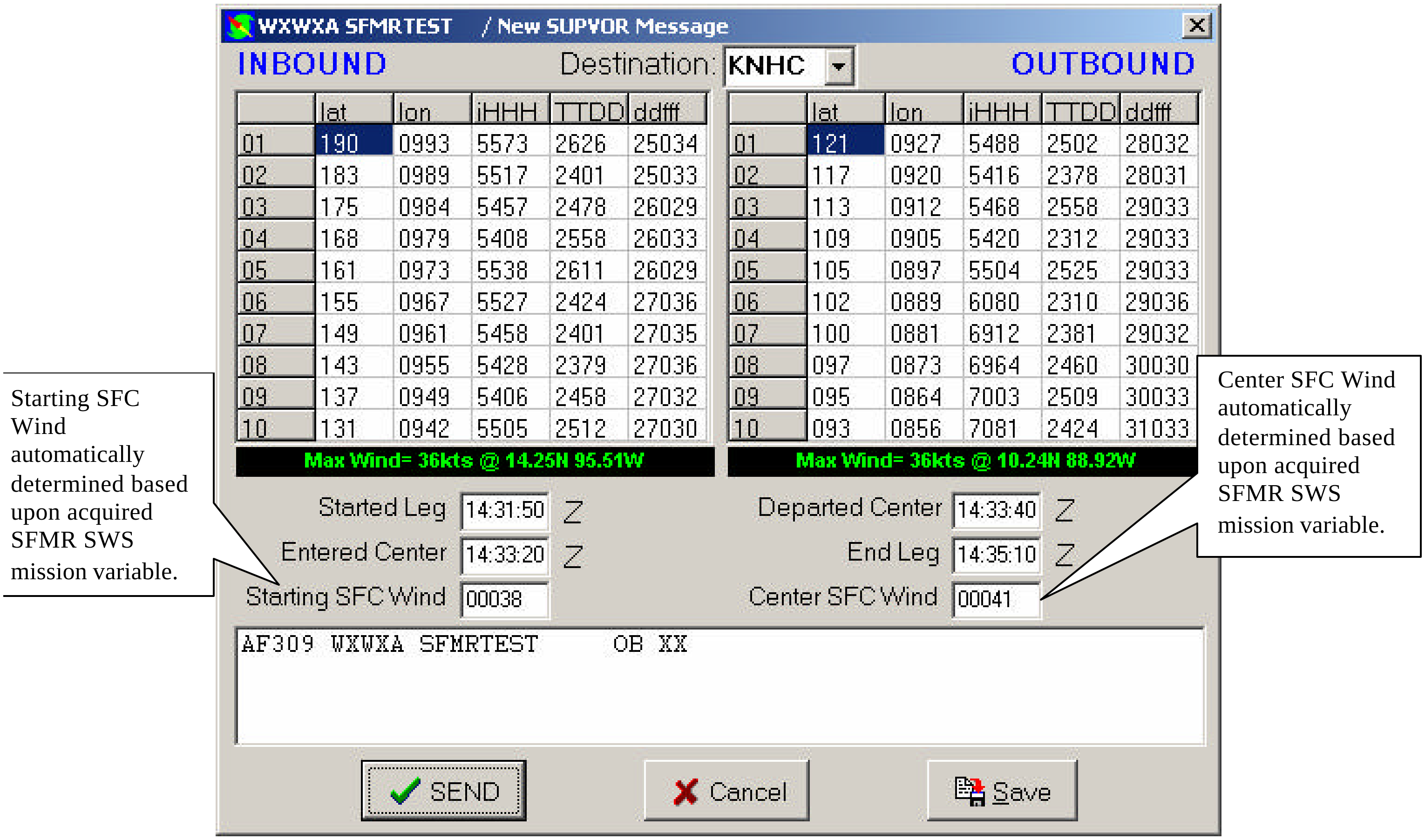


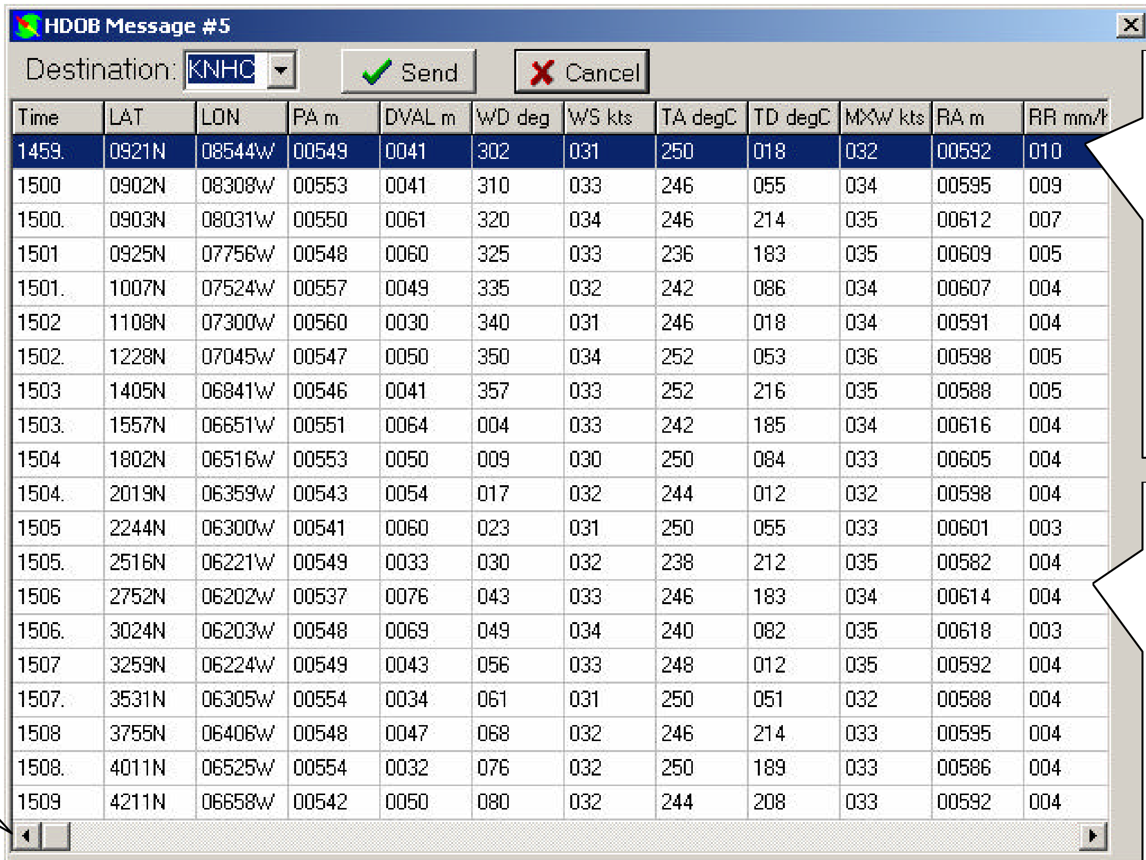
Figure 25 – ARWO Mission Manager SUPVOR Message – Data Auto Filled

3.4.8 ARWO Software HDOB Message Processing Modifications

The ARWO software HDOB (i.e., High Density Observation - HDOB message) message processing and HDOB message structure was modified to add the SFMR based mission variables of RR and SWS. These are newly added fields to the HDOB message, which alters the baseline structure of the HDOB message.

NOTE: The change to the HDOB message structure performed under this study would impact other elements of software that process this HDOB message. The WC-130J SATCOM Ground Station software would require modification to be compatible with this altered HDOB message structure. In addition, this HDOB message structure is processed by software at the National Hurricane Center (NHC), such that software that has been developed by personnel at NHC.

Most of the procedures and functions contained within the HDOBSource unit were modified under this study to support this modification to the HDOB message structure. The changes were rather extensive to support the addition of RR and SWS mission variables to the HDOB Message as well as be maintained within the HDOB Buffer. The HDOB Buffer is a data structure in memory that keeps every 30 second value of HDOB data from the start of a mission until the end of a mission. The run-time view of the HDOB Message and the HDOB Buffer are depicted in the following figures.



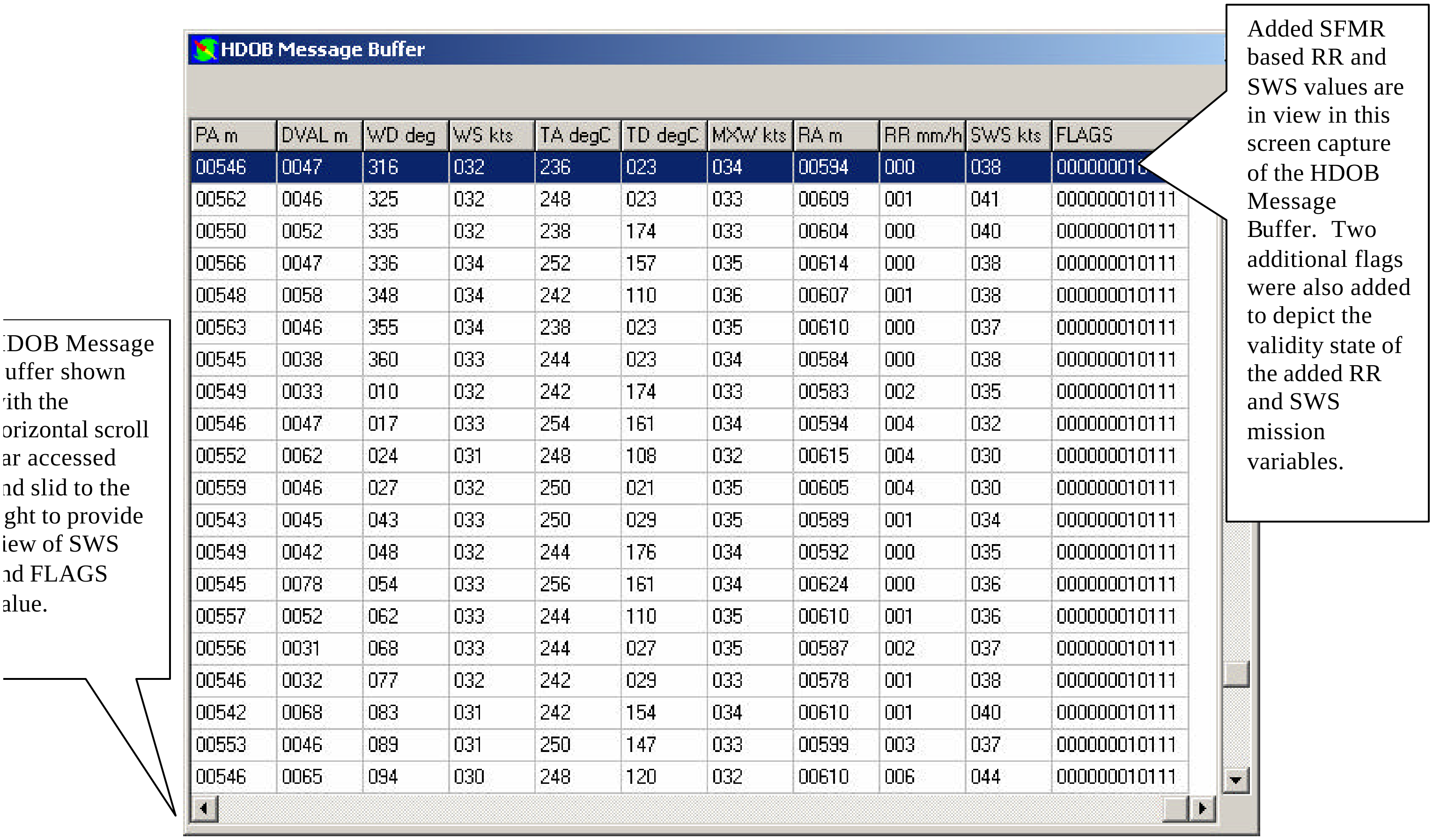
Time	LAT	LON	PA m	DVAL m	WD deg	WS kts	TA degC	TD degC	MXW kts	RA m	RR mm/h
1459.	0921N	08544W	00549	0041	302	031	250	018	032	00592	010
1500	0902N	08308W	00553	0041	310	033	246	055	034	00595	009
1500.	0903N	08031W	00550	0061	320	034	246	214	035	00612	007
1501	0925N	07756W	00548	0060	325	033	236	183	035	00609	005
1501.	1007N	07524W	00557	0049	335	032	242	086	034	00607	004
1502	1108N	07300W	00560	0030	340	031	246	018	034	00591	004
1502.	1228N	07045W	00547	0050	350	034	252	053	036	00598	005
1503	1405N	06841W	00546	0041	357	033	252	216	035	00588	005
1503.	1557N	06651W	00551	0064	004	033	242	185	034	00616	004
1504	1802N	06516W	00553	0050	009	030	250	084	033	00605	004
1504.	2019N	06359W	00543	0054	017	032	244	012	032	00598	004
1505	2244N	06300W	00541	0060	023	031	250	055	033	00601	003
1505.	2516N	06221W	00549	0033	030	032	238	212	035	00582	004
1506	2752N	06202W	00537	0076	043	033	246	183	034	00614	004
1506.	3024N	06203W	00548	0069	049	034	240	082	035	00618	003
1507	3259N	06224W	00549	0043	056	033	248	012	035	00592	004
1507.	3531N	06305W	00554	0034	061	031	250	051	032	00588	004
1508	3755N	06406W	00548	0047	068	032	246	214	033	00595	004
1508.	4011N	06525W	00554	0032	076	032	250	189	033	00586	004
1509	4211N	06658W	00542	0050	080	032	244	208	033	00592	004

orizontal croll Bar dded to access ll data and ags contained ithin HDOB lessages and DOB Message uffer. Form idth set to ax screen idth of 640, ence scroll bar as needed to ccess added ata of RR and WS variable nd two

Acquired SFMR data RR and SWS were added to HDOB Message and HDOB Message Buffer. Use added Horizontal scroll bar to access all the data and flags.

HDOB Message and HDOB Message Buffer are created using the same form. Destination field, and Send / Cancel buttons are only present on HDOB Messages.

Figure 26 – ARWO Mission Manager HDOB Message (Single Message)



PA m	DVAL m	WD deg	WS kts	TA degC	TD degC	MXW kts	RA m	RR mm/h	SWS kts	FLAGS
00546	0047	316	032	236	023	034	00594	000	038	000000010
00562	0046	325	032	248	023	033	00609	001	041	000000010111
00550	0052	335	032	238	174	033	00604	000	040	000000010111
00566	0047	336	034	252	157	035	00614	000	038	000000010111
00548	0058	348	034	242	110	036	00607	001	038	000000010111
00563	0046	355	034	238	023	035	00610	000	037	000000010111
00545	0038	360	033	244	023	034	00584	000	038	000000010111
00549	0033	010	032	242	174	033	00583	002	035	000000010111
00546	0047	017	033	254	161	034	00594	004	032	000000010111
00552	0062	024	031	248	108	032	00615	004	030	000000010111
00559	0046	027	032	250	021	035	00605	004	030	000000010111
00543	0045	043	033	250	029	035	00589	001	034	000000010111
00549	0042	048	032	244	176	034	00592	000	035	000000010111
00545	0078	054	033	256	161	034	00624	000	036	000000010111
00557	0052	062	033	244	110	035	00610	001	036	000000010111
00556	0031	068	033	244	027	035	00587	002	037	000000010111
00546	0032	077	032	242	029	033	00578	001	038	000000010111
00542	0068	083	031	242	154	034	00610	001	040	000000010111
00553	0046	089	031	250	147	033	00599	003	037	000000010111
00546	0065	094	030	248	120	032	00610	006	044	000000010111

Figure 27 – ARWO Mission Manager HDOB Message Buffer

The 10-second binary mission recorded file is accessed to compute and determine a 30 second average for both the added RR and SWS variables. The validity flags associated with each variable (i.e., validity flag for RR and SWS) are checked to determine the validity of the RR and SWS value indicated within the HDOB Message as well as what is kept within the HDOB Message Buffer. In addition, to these changes to the HDOBSource unit, there were changes to RawMsgSource form. The RawMsgSource form width was expanded to handle the display of the modified HDOB message without requiring the operator to resize the form. The form properties have been set to allow resize however. The raw message view of the new modified HDOB Message is illustrated in Figure 28 below.

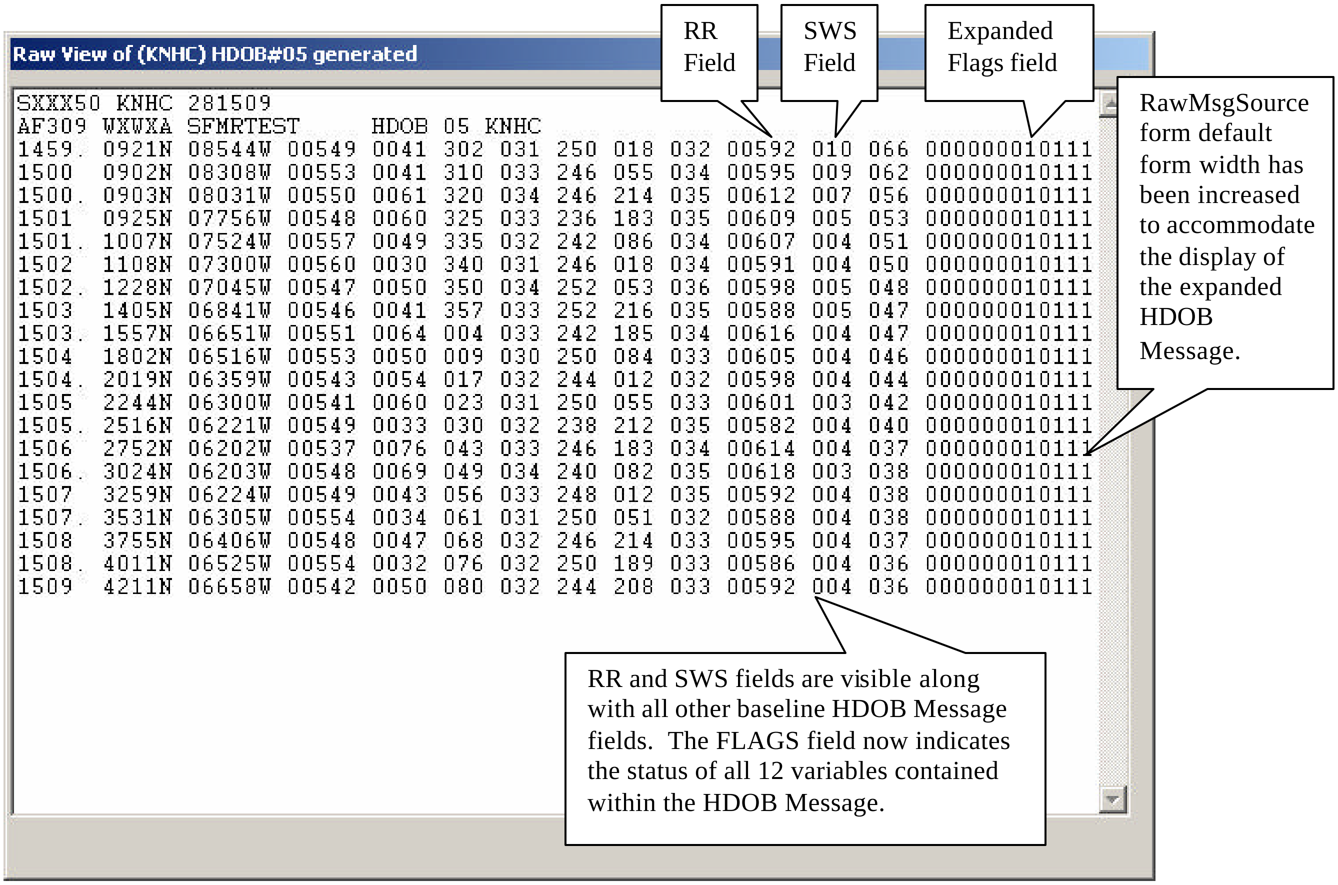


Figure 28 – ARWO Mission Manager HDOB Message (Raw Message View)

3.4.9 ARWO Software Version Compatibility

The changes to the ARWO software under this study do have an impact to version compatibility between one release of ARWO software and older releases of ARWO software. Since the changes under this study, directly change the 1 and 10-second binary file structure, the ability of versions of ARWO software to process and read these altered binary file structure is impacted. Now, under this study, in addition to the changes all previously described there were additional changes made to the ARWO software. The ARWO Mission Manager Export Mission software was modified to support the changes to the recorded 1 and 10-second binary mission files. The description of the changes to the ARWO Export Mission functionality is described in detail in the following section, as well as other changes that would be necessary to fully support the changes outlined under this study.

3.4.9.1 ARWO Software Mission Export Changes

The ExportMission unit was modified to support the changes made to the 1 and 10-second recorded mission binary files. The ExportRawData procedure within the ExportMission unit was modified to handle processing the additions of RR and SWS data contained within the recorded mission files. The modification made supports the generation of an ASCII text file of the newly modified binary file structure for the 1 and 10-second recorded mission files. The revised structure of the TOneSecondData record structure was described in section 2.4.3. In addition, the illustration of the modified 1 and 10-second recorded mission files are illustrated in Figure 16 and Figure 17.

The ARWO software was designed with a feature to support the functional/structural differences in the recorded mission file set between one version of ARWO software and another version of ARWO software. The two primary elements that support this are the File Version and Software Version fields that are embedded within the software, and recorded in the header of all mission files generated by ARWO software. Section 2.4.3 identifies the description of the THeaderRecord structure, which contains both the software version information (i.e., Major, Minor, Release, and Build fields) and the FileID (i.e., File version identifier). In addition, this section contains Figure 16, which illustrates the content of the Header information recorded/listed within each mission file.

The ARWO software under this study was not fully modified to make use of the FileID and Software Version information (i.e., Major, Minor, Release, and Build fields) written in the Header record of recorded mission files. However, the ARWO software could be modified to make full use of the FileID and Software Version information to provide backward compatibility with a new release of ARWO software with an older release of ARWO software. This study introduced for the first time a structural change to the recorded mission files, up to this point all previous production releases of ARWO software dealt only with one consistent file structure for the recorded mission files. For a future production release of ARWO software that made a structural change to the recorded mission file set, the ARWO software should be modified to process and handle differences between one file structure and another file structure.

3.4.9.2 ARWO Software Graph Manager Rebuild

As a result of the changes to the TOneSecondData record, which defines the structure for both the recorded 1 and 10-second mission binary files, the ARWO Graph Manager software must be rebuilt. The ARWO Graph Manager application processes and reads the recorded 10 second mission binary file for the generation of both a Time plot and Position plot. Since, the 10-second mission binary file changed, the ARWO Graph Manager software, which declares file objects of type TOneSecondData had to be rebuilt (i.e., recompiled and linked). There were no actual code changes that needed to be made to make the ARWO Graph Manager application capable of reading and plotting data from the modified 1 and 10-second mission binary files. Once the record structures and types specified within the TypePackage unit were made, the ARWO Graph Manager only needed to be rebuilt to be compatible with the new version of ARWO Mission Manager that generated mission files of this new record structure.

As noted before however, to have the ARWO Graph Manager application fully backward compatible with previous releases of ARWO software, code changes would be necessary. Additional logic would need to be added for the ARWO Graph Manager application to process the header record of recorded mission files to determine the FileID and Software Version information that generated the mission file. This additional software was not implemented under this study, as this was out of scope for this study. The ARWO software design does however directly support the addition of added logic to make use of FileID and Software Version information to support the direct backward compatibility of processing mission files generated from previous releases of ARWO software.

3.4.9.3 WC-130J Ground Station Software Impacts

As previously noted in section 2.4.8, changes made under this study would impact the WC-130J Ground Station software. The only change made under this study that would directly impact the WC-130J Ground Station software is the change to the HDOB message structure. The HDOB message structure under this study was modified to contain the RR and SWS variables, and validity flags for these variables. This both changed the structure and increased the size of the HDOB message from 1420 bytes to 1620 bytes. The WC-130J Ground Station GS Manager and GS Graph applications would need to be modified to handle this change to the HDOB message structure.

The WC-130J Ground Station GS Manager application would need to be changed because it processes and stores HDOB messages within the Message Log. In addition, the GS Manager application reads and parses the HDOB message and provides the operator a view of the contents of the HDOB message. These software functions will not work without a change to the GS Manager application to support the HDOB message structure changes.

The WC-130J Ground Station GS Graph application would need to be changed because it accesses and reads HDOB message files received over SATCOM. The HDOB message file is read by GS Graph to support Position Plot generation of a track, and data overlays and wind information overlays along the aircraft track. In addition, the GS Graph application accesses and reads the HDOB message files for generation of a Time Plot, plotting the data elements (i.e., LAT, LON, PA, DVAL, WD, WS, MXW, TA, TD, RA, and now RR and SWS) contained within the HDOB message. The GS Graph application functions of generating a Time Plot and Position Plot will not work without a change to the GS Graph application to support the HDOB message structure changes.

3.5 ARWO Computer Resource Evaluation

The affect on the ARWO computer resources was evaluated under this study. The memory usage and processor utilization was evaluated and compared against the current production baseline version (i.e., 15.400.20.8) of ARWO software. Table 8 below identifies the changes to both the ARWO Mission Manager and Graph Manager applications.

Table 8 – ARWO Computer Resource Comparison

ARWO SW Application	Image Size	Nominal Run-Time Memory Usage	Nominal CPU Utilization
ARWO Mission Manager - 15400208	1273 Kbytes	3708 Kbytes	12 %
ARWO Graph Manager - 15400208	612 Kbytes (612,352)	1896 Kbytes	
ARWO Mission Manager – SFMR Mod	1436 Kbytes	3724 Kbytes	16 %
ARWO Graph Manager – SFMR Mod	612 Kbytes (612,864)	1920 Kbytes	

The ARWO Software Mission Manager application that was adapted under this study was the baseline production version of 15400208 plus the changes to support SATCOM Controller migration as well as the modifications to support SFMR integration. The COM 4 port was enabled and configured in the ARWO computer to support interface with SFMR sensor subsystem. Table 2 defines the IRQ setting and I/O port address that was used to configure the COM 4 port. In addition, to this viable configuration setup for COM port 4, Table 3 shows the additional setup that could be configured for COM port 4 within the altered ARWO computer configuration that has been modified to support SATCOM Controller software migration.

The implementation of the integration of the ARWO computer/software with the SFMR sensor subsystem does fully utilize all serial asynchronous RS-232 I/O within the computer. However, the current 2-port serial asynchronous ISA card could be replaced with a 4 or 8-port card. This alternative serial card could be either an ISA card or a Peripheral Component Interface (PCI) card, as there is both spare ISA and PCI slots within the ARWO computer. There are drivers and libraries available for this type of multi-port serial I/O card to support interrupt sharing between the COM ports. Reference Figure 2 for the current production ARWO computer, and Figure 3 for the modified ARWO computer having upgraded the computer to support the SATCOM Controller migration software.

3.6 SFMR / ARWO Software Integration Study Summary

The ARWO computer and software integration with the SFMR sensor subsystem has been completed. The efforts associated with this study directly indicate that the ARWO computer and software can be adapted to interface with a SFMR sensor subsystem. The existing production ARWO computer has a spare serial asynchronous RS-232 interface port (i.e., COM port 4) that can be configured for interface to the SFMR sensor subsystem. Under this study, one of two prototype ARWO computers was actually configured to setup and enable operations using this spare serial RS-232 COM port (i.e., COM port 4). The SFMR sensor subsystem evaluated under this study, with data received via the government from the University of Massachusetts on the SFMR sensor subsystem, has a serial RS-232 interface for primary connection to an external computer system.

In addition, under this study the ARWO software was adapted to interface and process data received from the SFMR sensor subsystem. The version of ARWO software that was adapted under this study was a mix of the current production baseline software (version 15.400.20.8), with the added functionality developed into the ARWO software to support SATCOM Controller software migration (i.e., software changes developed under WC-130J ARWO Computer/Software upgrade study – reference Engineering Report LG01ER0044 titled "Engineering Report for WC-130J ARWO Computer/Software Upgrade Study"). This version of ARWO software was chosen to be adapted under this study, as it both represented the most computer resource intensive version of ARWO software, and a great likelihood of an actual future production version of ARWO software.

This study directly showed that the ARWO computer and software is fully capable of being adapted to interface/integrate with a SFMR sensor subsystem. The ARWO software was adapted to fully integrate the data received from the SFMR sensor subsystem into the existing ARWO software functionality. The modified ARWO software developed under this study was tested with a software simulation product provided by the University of Massachusetts. This simulation software output an ASCII data stream over a serial asynchronous RS-232 serial port similar to an actual SFMR sensor subsystem. The SFMR simulation software provided did not support two-way communication. The SFMR simulation only output a data stream simulating the output of the SFMR, and there was no data that could be passed back over the serial interface to command or control the SFMR sensor subsystem operations. Hence, the ARWO software was only modified to process the received data and integrate this data into existing functionality. Based upon discussions with NOAA and University of Massachusetts personnel, an actual SFMR sensor subsystem does support two-way communications over the serial RS-232 interface path. The ARWO computer and software is designed to support half duplex communications over the spare serial COM port (i.e., COM port 4). The command or control of the SFMR sensor subsystem could be added into the ARWO software under a Commercial Engineering Change Proposal (CECP) contract to implement this functionality into the WC-130J aircraft.

This study has directly defined a new ARWO computer configuration and software functionality that could be added to the WC-130J aircraft. This functionality would give advanced capabilities to the WC-130J aircraft over the current WC-130H aircraft, and greatly improve the operational storm mission.

The implementation of this study into the aircraft would require the software developed under this study to be officially configuration controlled and formally qualification tested. The ARWO software documentation set (i.e., Software Requirement Specification, Software Design Document, Software Product Specification, Software Test Description, Software Test Report, Software User's Manual, Software Version Description) would have to be updated to support the implementation of this functionality into the WC-130J aircraft. In addition, to the ARWO software, the WC-130J SATCOM Ground Station software would require being updated to handle the modifications to the HDOB message file generated by the ARWO software. The HDOB message is also sent to the National Hurricane Center (NHC) computer system and Automated Weather Network (AWN). These systems would likely also require a software change to handle this modified HDOB message file. The ARWO console would require modifications for the addition of serial RS-232 wiring between the ARWO computer and the SFMR sensor subsystem. The WC-130J aircraft wiring would require modification to support this serial RS-232 connection from the ARWO Station Interface Panel on the sidewall of the aircraft to the SFMR sensor subsystem controller.

In general, the implementation of the capabilities evaluated and developed under this study for the ARWO computer/software could be implemented within the WC-130J aircraft with little to no risk, and only involving minor modifications to the ARWO console, ARWO computer, ARWO software, and aircraft wiring.

4.0 SFMR Integration Study - Design Concepts

4.1.1 Configuration - Wing Installation, Fuel Tank Mounted SFMR

4.1.1.1 Description

The fuel tank mounted SFMR is contained within a specially modified version of the current configuration standard wing mounted fuel tank provided by Sargent Fletcher, Inc. For the purposes of this study we shall consider part number 305J001 fuel tank that can be modified to house the SFMR. This configuration is similar to what was accomplished with the Samson pod that is used for open skies treaty verification.

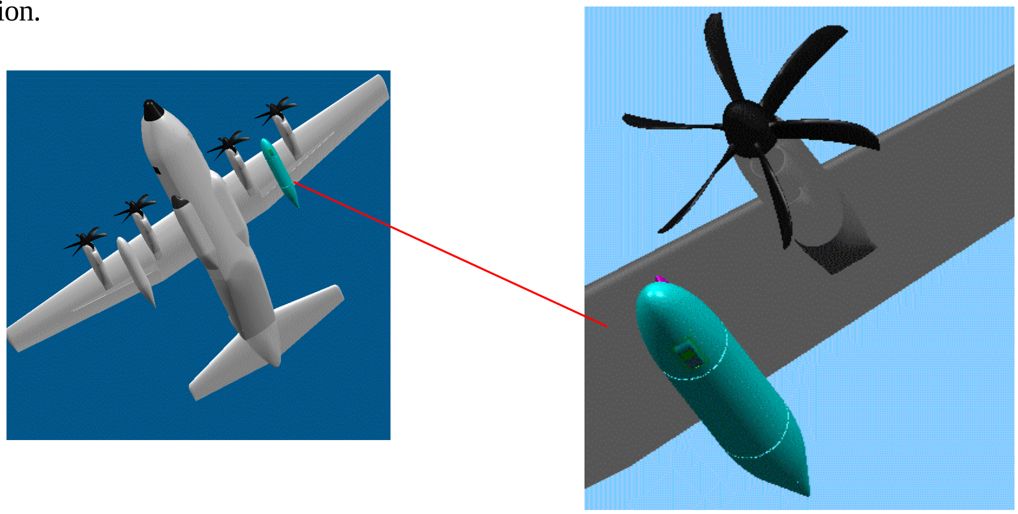


Figure 29 – Wing Installation, Fuel Tank Mounted SFMR

4.1.1.2 Construction

The fuel tank is a separable assembly that consists of three sections; a forward section or nose cone, a mid section & an aft section. The aft section has an aerodynamic fairing. The sections are inter-connected & sealed to prevent leakage. This feasibility study will consider sealing off the forward portion of a fuel tank with the aft two sections retaining fuel management capability.

A fuel barrier could be fabricated to reside within the forward part of the fuel tank mid section. The barrier would be made of aluminum and welded or mechanically fastened to the mid section. It would be reinforced to act as a support base for a support structure.

A framework structural support system could be fabricated to nest within the nose cone of the tank similar to what is shown to the right. The supports can be either a welded or mechanically fastened simple truss system utilizing 6061 aluminum extrusion stock. The SFMR unit could be attached at hardpoints to shock mounts.

The nose cone would require a cutout to permit operation of the antenna and receiver. A radome aerodynamically fashioned of a material such as what is currently used on the SFMR (Rexolite) or equivalent could be mechanically fastened to the nose cone and provide a weather resistant barrier that would permit antenna reception.

A penetration could be made in the mid section fuel barrier to provide a connection for wiring to pass through via double wall stainless steel tubing to provide a means for system interconnection. The wire routing developed for the Samson system utilizing existing flap well runs and a feed through at the BL 61 bulkhead is a proven method that could be applied to this configuration.

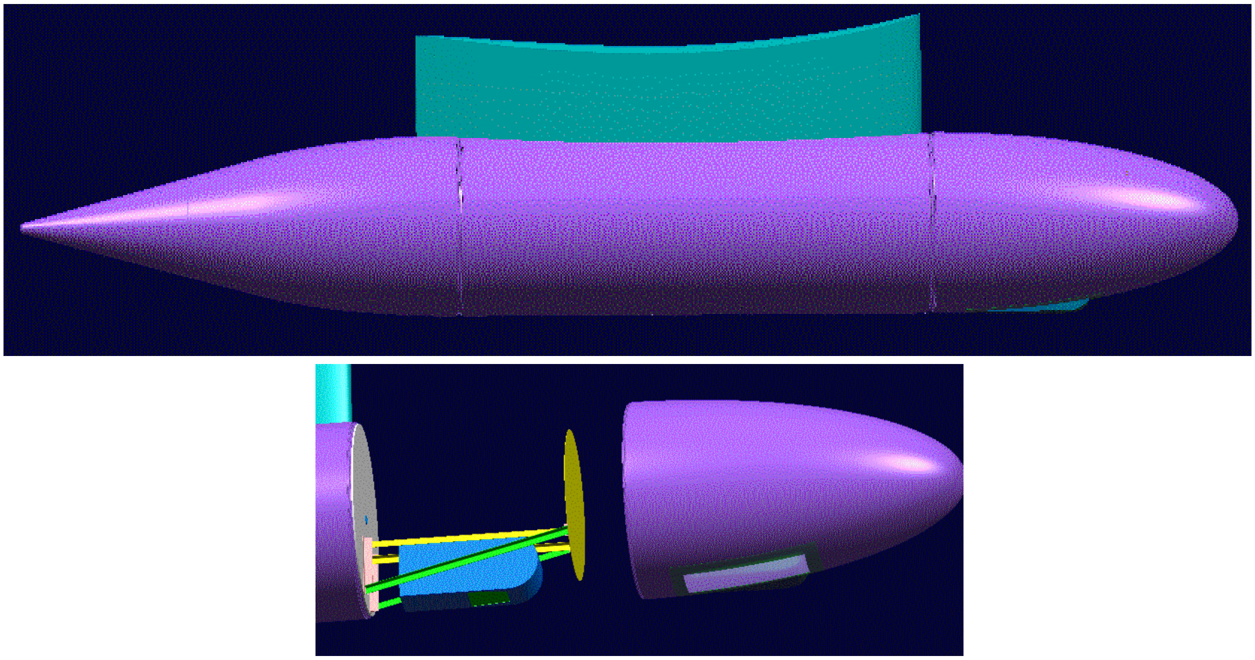


Figure 30 – Wing Installation, Fuel Tank Mounted SFMR, Nose Cone Removed Impact - Wing Installation, Fuel Tank Mounted SFMRStructures

Considering the design of the fuel tank, it's feasibility as a platform for conducting in-flight analysis of atmospheric phenomena is excellent. The weight of the support structure in combination with the SFMR should not exceed that of the fuel being displaced (the SFMR weighs approximately 40 lb). Therefore the standard pylon and wing attachment configuration would not require modification. A study of the weight and balance differential effects on the pylon would need to be conducted to determine the validity of this.

The usage of a simple truss type support system similar to what was developed for the Samson pod is a cost effective method. The simplicity of the system makes it an attractive option. The usage of appropriately sized shock mount isolators will provide a measure of control with respect to vibration. The tubing feed thru within the fuel area may require support due to the length of the tubing run. The cutout in the nose cone would need to be structurally reinforced and the fairing should not inhibit SFMR functionality.

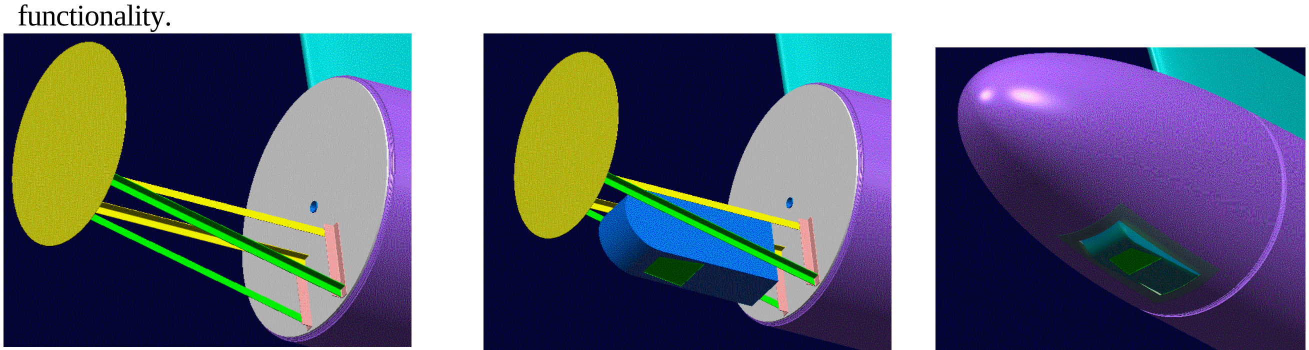


Figure 31 – Fuel Tank Mounted SFMR, Structural Configuration

4.1.2.2 Systems

The displacement of fuel within the fuel tank and replacement with structure has to be evaluated from a mass balance standpoint. The opposite wing fuel tank fuel levels may need to be adjusted for CG control.

By removing the standard band clamp that attaches the forward section to the rest of the tank, access to the SFMR unit can be attained. The unit should be removable with quick disconnects provided in the area within the nose cone and at the location of the shock mount isolators. Additional quick disconnects should be provided at the exit location of the tank.

The SFMR unit does not require environmental control since it is a self-contained unit that has built-in failsafe features to prevent overheating, limit power consumption and provide electronic heating to maintain system calibration.

The wire routing along the flap well run has to be assessed to ensure that the external cables are not routed along side other cable that carry high electric current. The routing should not exceed 200 feet in length. Shielded cable should be considered for use with this system.

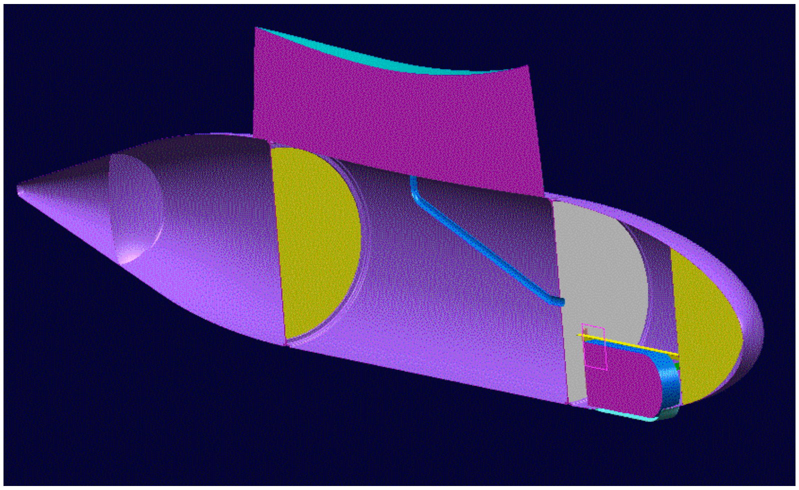


Figure 32 – Fuel Tank Mounted SFMR, Cutaway View

4.1.2.3 Operations

Since the unit should be mounted far from radar and radio antennae, the location within the fuel tank is optimal. However it would be recommended that an operational spectrum analysis be conducted to determine operational system impact. Blanking signal functionality would then be derived and incorporated to ensure optimal system operation.

Mass balance for CG control and fuel displacement issues affect range and fuel transfer considerations.

The SFMR requires thermal warm-up that typically takes 30 minutes. The warm up period begins automatically after the instrument is powered on.

A visual inspection of the radome to ensure that it is not damaged and is free of contaminants (oil, fuel etc.) is a preflight consideration.

4.1.3 Benefits - Wing Installation, Fuel Tank Mounted SFMR

The benefits associated with incorporation of the SFMR system into the WC-130J platform via a modified fuel tank include adaptability. The proposed configuration is readily adaptable to the WC-130J since the modified fuel tank is interchangeable with the current wing tank. Wiring provisions would have to be made, but the system would be readily interchangeable if an alternative military transport mission had to be performed. Another benefit is that the concept is proven and thereby lessons learned can be garnered to apply to the design of the modified fuel tank for SFMR integration. A customer (Sargent Fletcher) already produces the Samson pod and could be used to develop the modified fuel tank for this application. Wire routings and structural accommodations have been developed to support the integration of the Samson pod and could be used for this application.

Another benefit is that by locating the SFMR in a fuel tank out on the wing minimizes the effects of radiating sources operating on the aircraft. While the SFMR system can operate in an environment local to radiation sources such as C-band radar or radar altimeter, the effects are minimized by location on the wing.

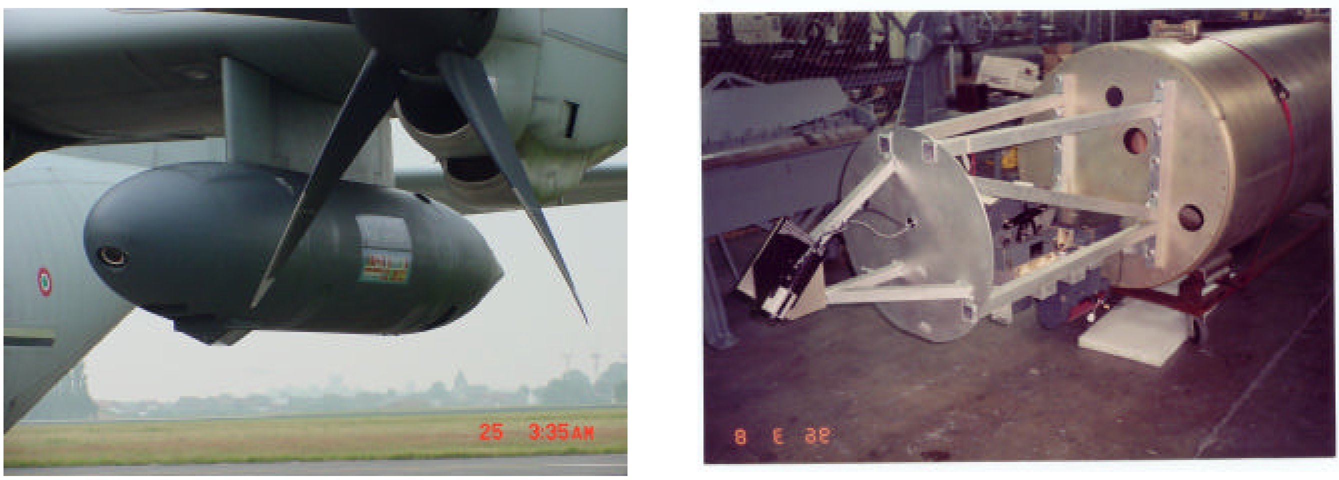


Figure 33 – Samson Pod

4.1.4 Risks - Wing Installation, Fuel Tank Mounted SFMR

The risks associated with incorporation of the SFMR system into the WC-130J platform via a modified fuel tank include wire routing length. If the routing to the ARWO station exceeds 200 feet and the system cannot be modified to accommodate a greater length, this configuration is not feasible. While the concept of using a standard wing mounted fuel tank as a pod has been proven, combining instrumentation used to gather data with the functional fuel containment and management system has not been devised. Fuel displacement within the fuel tank(s) will impact the range of the WC-130J. The range effect may be significant but will need to be evaluated for mission impact.

4.1.5 Analysis & Test Issues

4.1.5.1 Aerodynamics

Aerodynamic activities associated with SFMR integration using a wing mounted fuel tank would involve coordinating with design to develop the fairing for the nose cone cutout and determining the fuel displacement effect on the range.

For an average cruise condition of 130,000 pound aircraft at 31,000 feet altitude flying at long range cruise speed (310 KTAS) the mission range will decrease approximately 80NM/1000 pounds of fuel displaced by the SFMR installation. The drag increase for this configuration is negligible.

4.1.5.2 EMI

EMI activities associated with SFMR integration using a wing mounted fuel tank would involve conducting a spectrum analysis of the aircraft and determining the impact to the system through coordination with the vendor and avionics/software.

4.1.5.3 Vibroacoustics/Loads

Vibroacoustics/loads activities associated with SFMR integration using a wing mounted fuel tank would involve analysis of the proposed design for weight and balance to determine effects of having a dry bay at the forward end of the tank, displacement of fuel and the effects on aircraft symmetry and CG control, fuel tank pressure analysis, dry bay pressure differential and the effects on the SFMR, development and analysis of structural and vibroacoustic loads on the support structure as well as sizing of vibration isolators that interface between the structural support system and the SFMR.

4.1.5.4 Stress

Stress analysis activities associated with SFMR integration using a wing mounted fuel tank would involve verification of the loads determination on the structural support system and analysis of the proposed support system configurationto ensure loads requirements are met. Additionally a testing and qualification program would be required to certify the new modified pod.

4.1.5.5 Reliability & Maintainability

R & M activities associated with SFMR integration using a wing mounted fuel tank would involve development of a preventive maintenance program to purge the receiver enclosure with nitrogen gas and develop a plan for annual calibration of the SFMR These activities will evolve with the development of an R&M Program Plan and update of the LSAR Database for the WC-130J.

4.1.5.6 Safety

Safety activities associated with SFMR integration using a wing mounted fuel tank would involve an assessment of the design with respect to electronics in combination with fuel, power overload protection, the wire routing through the fuel cell and along the flap well to the penetration through the pressure barrier to the ARWO station.

4.1.5.7 Software/Avionics

Software/avionics activities associated with SFMR integration using a wing mounted fuel tank would involve coordination with the vendor and EMI to determine all of the intercommunication aspects of the design.

4.2 Configuration - Wing Installation, Pod/Pylon Mounted SFMR

4.2.1.1 Description

The wing tip mounted SFMR is contained within a pod mounted to the wing via a pylon at the standard outboard wing station (OWS) mounting location (OWS 330.10). For the purposes of this study we shall consider a pod configuration that is similar in size and shape to what was proposed by Zivko, Inc. to house the SFMR. Also, we shall consider that an SFMR specific pylon shall be proposed. The pylon to pod interface could be similar to what is used for the aerial refueling pod on KC-130J aircraft operated by the Marine Corps. Considering that the loads due to the SFMR/pod combination are a great deal less than the refueling pod, an SFMR pod specific pylon would be optimal.

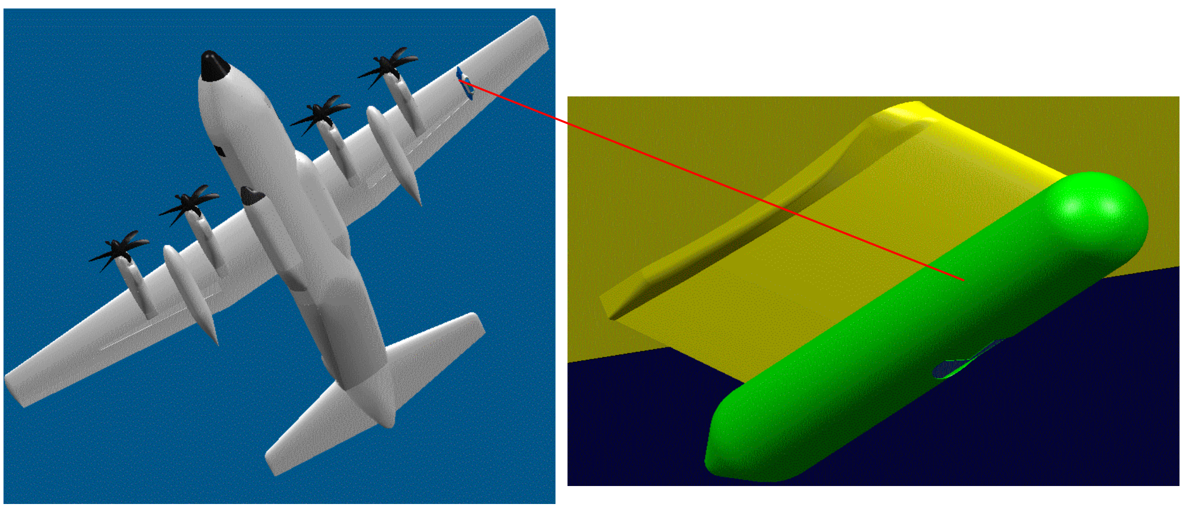


Figure 34 – Wing Installation, Pod/Pylon Mounted SFMR

4.2.1.2 Construction

The pod is a separable assembly that consists of two sections. The upper section contains interface structure for mounting the pod to the pylon. Also, the upper section provides the interface for the SFMR support structure to the pod.

The lower section is removable and provides access to the SFMR and adjacent support structure and acts primarily as a fairing. The pod outer skin could be made of a suitable composite material such as carbon fiber composite or fiberglass reinforced plastic. The use of composites in this area is desirable. A framework structural support system could be fabricated to nest within the pod similar to what is shown to the right. The support structure could be made of aluminum and mechanically fastened to the upper portion of the pod skin. The supports can be either a welded or mechanically fastened system utilizing 6061 aluminum sheet and extrusion stock. The SFMR unit could be attached at hardpoints to shock mounts. A radome, fashioned of a material such as what is currently used on the SFMR (Rexolite) or equivalent would be provided at the bottom of the pod lower section. The radome provides a weather resistant barrier that would permit antenna reception.

The wire routing utilizing existing flap well runs and a feed through at the BL 61 bulkhead is a proven method that could be applied to this configuration. Impact - Wing Installation, Pod/Pylon Mounted SFMRStructures

Existing OWS hard-points would be utilized for this configuration. Structural modifications should not be required to support this system at the wing to pylon interface. A modification to the BL 61 bulkhead to provide a feed through for the wire routing similar to what is done to support the Samson pod electronics interface would be required.

The development of an SFMR specific pod/pylon configuration is desirable. However, the pod interface should be designed to be compatible the pylon utilized for refueling pods. The development of the support system configuration is dependent upon the location of hard-points within the SFMR. The usage of appropriately sized shock mount isolators will provide a measure of control with respect to vibration. The structural support renditions are simple at best and based on pictures provided by the vendor, ProSensing.

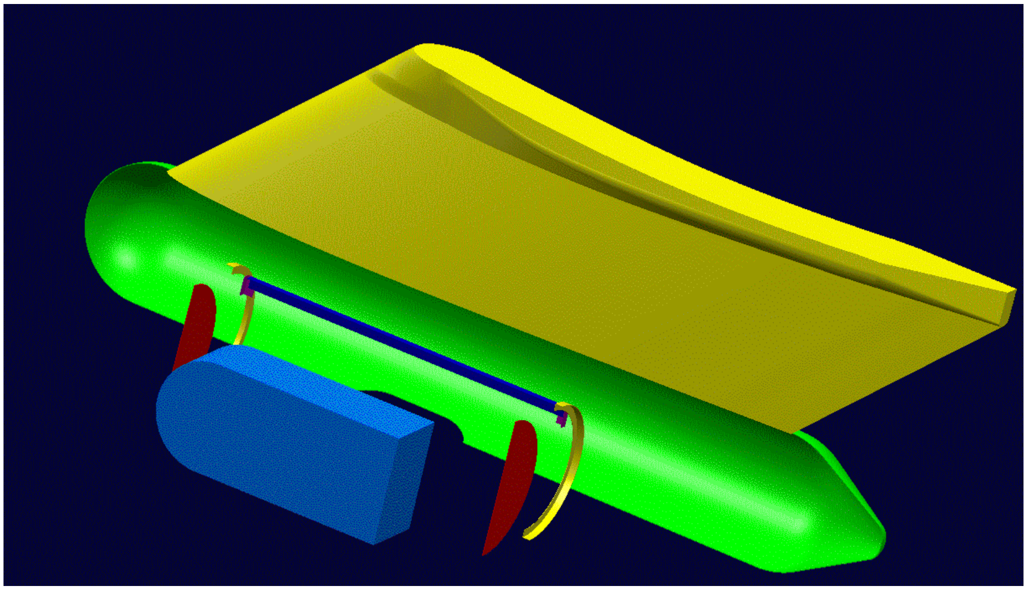


Figure 35 – Pod and SFMR Support Concept

4.2.2.2 Systems

Access to the SFMR unit would be gained by disconnecting the lower section of the pod from the upper section. The SFMR would then be able to be removed from the upper support structure at the shock mount isolators. This would provide easy access for periodic maintenance such as cleaning prior to flight.

Quick disconnects should be provided at the location of the shock mount isolators. Additional quick disconnects should be provided at the top of the pod adjacent to the structural mounting location.

The SFMR unit does not require environmental control since it is a self-contained unit that has built-in failsafe features to prevent overheating, limit power consumption and provide electronic heating to maintain system calibration.

The wire routing along the flap well run has to be assessed to ensure that the external cables are not routed along side other cable that carry high electric current. The routing should not exceed 200 feet in length. Shielded cable should be considered for use with this system.

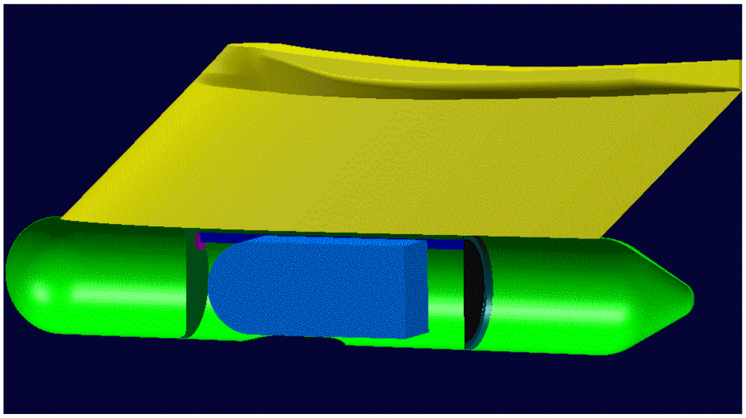


Figure 36 – Wing Installation, Pod and Pylon Mounted SFMR Cutaway View

4.2.2.3 Operations

Since the unit should be mounted as far as possible from radar and radio antennae, the outboard wing mounting location is optimal. However it would be recommended that an operational spectrum analysis be conducted to determine operational system impact. Blanking signal functionality would then be derived and incorporated to ensure optimal system operation.

Initial aero estimates suggest that due to the size of the proposed pod and pylon, a lack of symmetry is not a cause for concern. However, consideration of potential air speed limitations must be addressed since these limitations directly affect the mission profile. A complete analysis would have to be accomplished to determine the extent of the effects caused by the pod and pylon to the aircraft performance envelope. The SFMR requires thermal warm-up that typically takes 30 minutes. The warm up period begins automatically after the instrument is powered on.

Preflight tasks include conducting a visual inspection. The radome has to be inspected to ensure that it is not damaged and is free of contaminants (oil, fuel etc.).

4.2.3 Benefits - Wing Installation, Pod/Pylon Mounted SFMR

The benefits associated with incorporation of the SFMR system into the WC-130J platform via a pod and pylon mounted to the OWS include adaptability. The proposed configuration is readily adaptable to the WC-130J since provisions exist at OWS 330.10 for attaching a pylon. The weight of the system would be accommodated by the existing structure and wiring provisions would have to be made, but the system could be readily interchangeable if an alternative military transport mission had to be performed. Another benefit is that the concept of mounting a pylon and pod is proven. Similar to the fuel tank mounted SFMR, lessons learned can be applied to the design of the pylon and pod for SFMR integration. A customer (Zivko, inc.) Has already been approached by the SFMR vendor ProSensing about producing a pod for the SFMR. The configuration proposed by Zivko has been modeled and presented for this concept. Wire routings and structural accommodations have been developed to support the integration of the Samson pod and could be used for this application. Another benefit is that by locating the SFMR in a pod out on the wing minimizes the effects of radiating sources operating on the aircraft. While the SFMR system can operate in an environment local to radiation sources such as C-band radar or radar altimeter, the effects are minimized by location on the wing.

4.2.4 Risks - Wing Installation, Pod/Pylon Mounted SFMR

The risks associated with incorporation of the SFMR system into the WC-130J platform via a pod and pylon mounted to the OWS include wire routing length. If the routing to the ARWO station exceeds 200 feet and the system cannot be modified to accommodate a greater length, this configuration is not feasible. Also, the pod and pylon design may induce some airspeed limitations on the aircraft that would impact the mission profile. The range effect is not significant due to the installation of a pod and pylon at the OWS location but it will need to be evaluated for mission impact.

4.2.5 Analysis & Test Issues

4.2.5.1 Aerodynamics

Aero activities associated with SFMR integration using an OWS mounted pylon/pod would involve coordinating with design to develop the pylon and pod configuration and determining the effect on the range as well as flight characteristics.

Although this configuration is asymmetric, no impact to flying characteristics is anticipated. The drag estimate for this pylon/pod configuration is approximately 5 counts, which results in less than 1% reduction in cruise range. The trim effects resulting from the pod drag is small; 3 degrees of rudder tab trim is estimated to trim the aircraft in cruise. No change in stall characteristics or stall performance is anticipated. The stick pusher will prevent the aircraft from reaching aerodynamic stall, thus avoiding the possibility of the wing with the pod installation stalling before the clean wing. Flight tests, with the in-flight refueling pods located in the same position as the SFMR pod, show no degradation in maximum lift performance.

4.2.5.2 EMI

EMI activities associated with SFMR integration using an OWS mounted pylon/pod would involve conducting a spectrum analysis of the aircraft and determining the impact to the system through coordination with the vendor and avionics/software.

4.2.5.3 Vibroacoustics/Loads

Vibro/loads activities associated with SFMR integration using an OWS mounted pylon/pod would involve analysis of the proposed design for weight and balance to determine effects of having a non-symmetric configuration on the aircraft wing. Vibro/loads will have to conduct an analysis of the effects on aircraft symmetry and cg control, development and analysis of structural and vibroacoustic loads on the support structure as well as sizing of vibration isolators that interface between the structural support system and the SFMR.

4.2.5.4 Stress

Stress analysis activities associated with SFMR integration using an OWS mounted pylon/pod would involve verification of the loads determination on the structural support system and analysis of the proposed support system configuration to ensure loads requirements are met. . Additionally a testing and qualification program would be required to certify the new pod.

4.2.5.5 Reliability & Maintainability

R & M activities associated with SFMR integration using an OWS mounted pylon/pod would involve development of a preventive maintenance program to purge the receiver enclosure with nitrogen gas and develop a plan for annual calibration of the SFMR. These activities will evolve with the development of an R&M Program Plan and update of the LSAR Database for the WC-130J.

4.2.5.6 Safety

Safety activities associated with SFMR integration using an OWS mounted pylon/pod would involve an assessment of the design with respect to flight limitations associated with the non-symmetrical installation of a pylon/pod on one wing. Also, the wire routing along the flap well to the penetration through the pressure barrier to the ARWO station would have to be assessed.

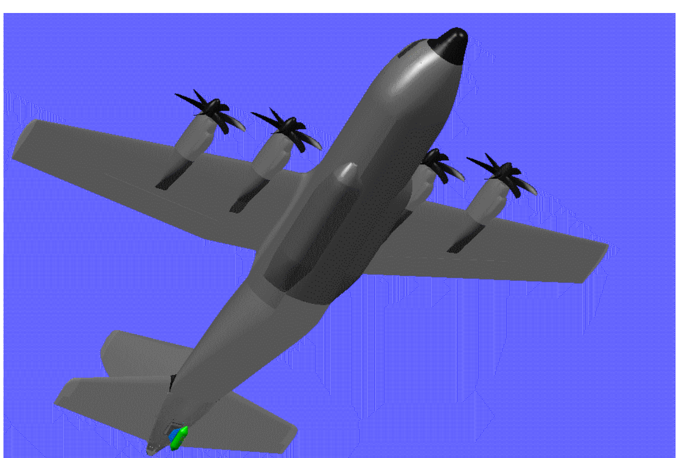
4.2.5.7 Software/Avionics

Software/avionics activities associated with SFMR integration using an OWS mounted pylon/pod would involve coordination with the vendor and EMI to determine all of the intercommunication aspects of the design.

4.3 Configuration – Empennage Installation, Pod/Pylon Mounted SFMR

4.3.1.1 Description

The empennage mounted SFMR is contained within a pod mounted to the aircraft via a pylon at a newly developed mounting location along the centerline and at FS 1127. For the purposes of this study we shall consider a pod configuration that is similar in size and shape to what was proposed by Zivko, Inc. To house the SFMR, a pylon will have to be developed to mount to the new support structure. The pylon to pod interface could be similar to what is used for the aerial refueling pod on KC-130J aircraft operated by the Marine Corps. The pylon and pod could be removed from the aircraft for alternative mission requirements but the new support structure would be permanent structure concealed by a fairing.



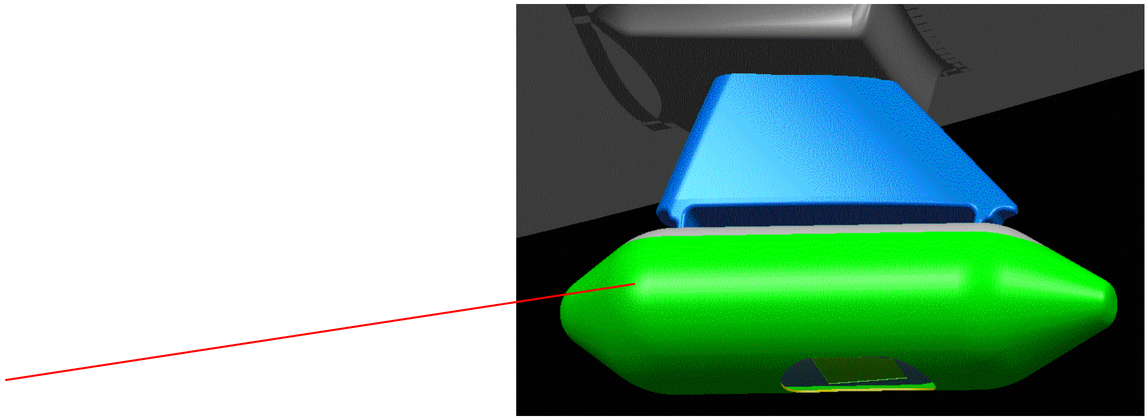


Figure 37 – Empennage Installation, SFMR in Pod Attached To Pylon

4.3.1.2 Construction

The pod is a separable assembly that consists of two sections. The upper section contains interface structure for mounting the pod to the pylon. Also, the upper section provides the interface for the SFMR support structure to the pod.

The lower section is removable and provides access to the SFMR and adjacent support structure and acts primarily as a fairing. The pod outer skin could be made of a suitable composite material such as carbon fiber composite or fiberglass reinforced plastic. The use of composites in this area is desirable. A framework structural support system could be fabricated to nest within the pod similar to what is shown to the right. The support structure could be made of aluminum and mechanically fastened to the upper portion of the pod skin. The supports can be either a welded or mechanically fastened system utilizing 6061 aluminum sheet and extrusion stock. The SFMR unit could be attached at hard points to shock mounts. A radome, fashioned of a material such as what is currently used on the SFMR (Rexolite) or equivalent would be provided at the bottom of the pod lower section. The radome provides a weather resistant barrier that would permit antenna reception.

The aircraft structure adjacent to the pylon attachment location would have to be modified to provide for a structural support system. The structural support system would be permanent with a fairing developed to conceal the location. A wire routing utilizing existing runs for defensive systems could be developed to accommodate the pod and pylon configuration.

4.3.2 Impact - Empennage Installation, Pod/Pylon Mounted SFMR

4.3.2.1 Structures

As stated previously, the aircraft structure adjacent to the pylon attachment location would have to be modified to provide for a structural support system. This can be accomplished without affecting other systems such as the elevator linkage which resides above, or the chaff and flare dispensers which reside forward of the proposed attachment location. The internal aircraft structure would have to be modified similar to what was accomplished for the EC-130J that provides for attachment of the HTWA in this area. At FS 1127, the 370288-1 cap and at FS 1138, the 370300-1 cap provide excellent locations to attach new support structure. Internal modifications to the existing structure such as additional intercostals and skin doublers local to the fairing attachment area would be required. The development of the support system configuration is dependent upon the location of hard points within the SFMR. The usage of appropriately sized shock mount isolators will provide a measure of control with respect to vibration. The structural support renditions are simple at best and based on pictures provided by the vendor, ProSensing.

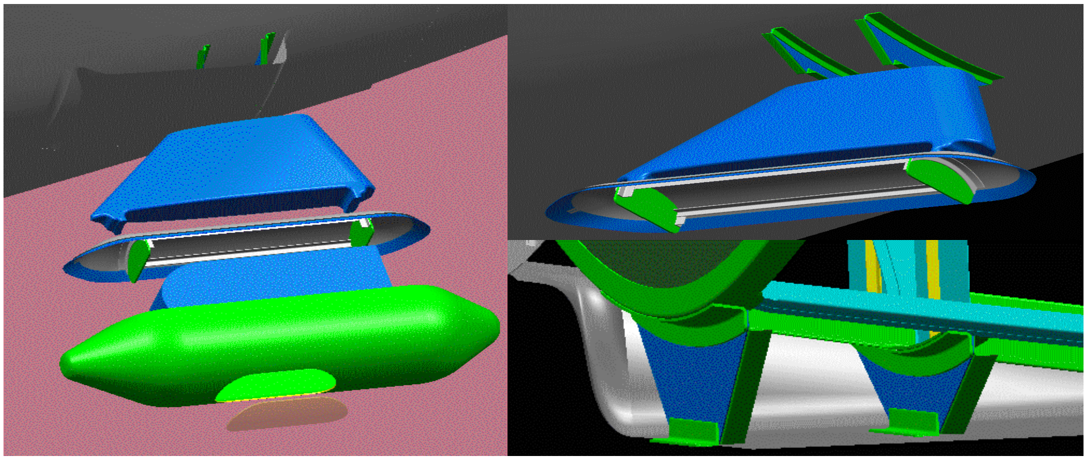


Figure 38 – Empennage Installation, Pod, Pylon and Support System

4.3.2.2 Systems

Access to the SFMR unit would be gained by disconnecting the lower section of the pod from the upper section. The SFMR should be able to be removed from the upper support structure at the shock mount isolators. This would provide easy access for periodic maintenance such as cleaning prior to flight.

Quick disconnects should be provided at the location of the shock mount isolators. Additional quick disconnects should be provided at the top of the pod adjacent to the pylon mounting location.

The SFMR unit does not require environmental control since it is a self-contained unit that has built-in failsafe features to prevent overheating, limit power consumption and provide electronic heating to maintain system calibration.

A wire routing utilizing existing runs for defensive systems has to be assessed to ensure that the external cables are not routed along side other cable that carry high electric current. The routing should not exceed 200 feet in length. Shielded cable should be considered for use with this system.

4.3.2.3 Operations

Since the unit should be mounted as far as possible from radar and radio antennae, the empennage mounting location is adequate. However it would be recommended that an operational spectrum analysis be conducted to determine operational system impact. Blanking signal functionality would then be derived and incorporated to ensure optimal system operation.

Initial aero estimates suggest that the location selected is in a turbulent flow field. Therefore, air speed limitations would not be in force and the mission profile would not be affected. A complete analysis would have to be accomplished to determine the extent of the effects caused by the pod and pylon to the aircraft performance envelope.

The SFMR requires thermal warm-up that typically takes 30 minutes. The warm up period begins automatically after the instrument is powered on.

Preflight tasks include conducting a visual inspection. The radome has to be inspected to ensure that it is not damaged and is free of contaminants (oil, fuel etc.).

4.3.3 Benefits - Empennage Installation, Pod/Pylon Mounted SFMR

A benefit associated with incorporation of the SFMR system into the WC-130J platform via a pod and pylon mounted to the empennage is adaptability. After the incorporation of the necessary structural modifications, the proposed configuration would be easily removed from or installed to the aircraft depending on mission requirements. The HTWA installation on the EC-130J is a permanent installation whereas this proposed configuration is removable.

Another benefit is that the empennage mounted SFMR concept is similar to the HTWA on the EC-130J. Lessons learned can be applied to the design of the support structure for pylon and pod integration. A customer (Zivko, Inc.) Has already been approached by the SFMR vendor ProSensing about producing a pod for the SFMR. The configuration proposed by Zivko has been modeled and presented for this concept. Wire routings and structural accommodations have been developed to support the integration of the HTWA and could be used for this application. Another benefit is that by locating the SFMR in a pod out on the empennage minimizes the effects of radiating sources operating on the aircraft. While the SFMR system can operate in an environment local to radiation sources such as C-band radar or radar altimeter, the effects are minimized by location on the empennage.

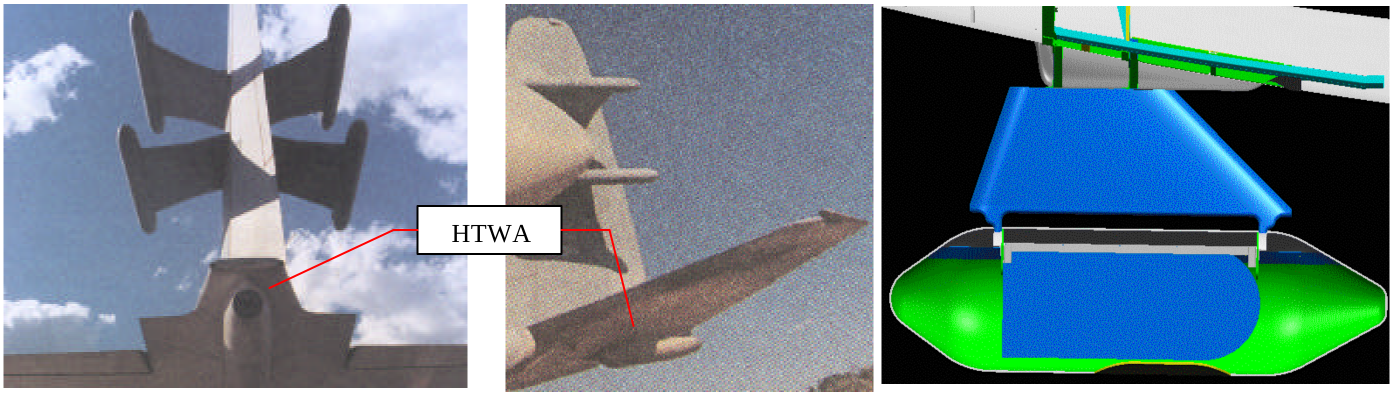


Figure 39 – HTWA Installation on EC-130 and Empennage Mounted Concept

4.3.4 Risks - Empennage Installation, Pod/Pylon Mounted SFMR

The risks associated with incorporation of the SFMR system into the WC-130J platform via a pod and pylon mounted to the empennage include consideration of EMI effects. A spectrum analysis of the aircraft would be required to determine the extent of the impact. In addition, the pod and pylon design may induce some flight limitations on takeoff angle that could impact the mission profile. Also the redesign effort for this location would be considerable as there has been no existing attach point for this location on production aircraft.

4.3.5 Analysis & Test Issues

4.3.5.1 Aerodynamics

Aero activities associated with SFMR integration using an empennage mounted pylon/pod would involve coordinating with design to develop the pylon and pod configuration and determining the effect on the range as well as flight characteristics.
The drag estimate for this pylon/pod configuration is approximately 5 counts, which results in less than 1% reduction in cruise range.

4.3.5.2 EMI

EMI activities associated with SFMR integration using an empennage mounted pylon/pod would involve conducting a spectrum analysis of the aircraft and determining the impact to the system through coordination with the vendor and avionics/software.

4.3.5.3 Vibroacoustics/Loads

Vibro/loads activities associated with SFMR integration using an empennage-mounted pylon/pod would involve analysis of the proposed design for weight and balance effects. Vibro/loads will have to conduct an analysis of the effects on cg control, development and analysis of structural and vibroacoustic loads on the support structure as well as sizing of vibration isolators that interface between the structural support system and the SFMR.

4.3.5.4 Stress

Stress analysis activities associated with SFMR integration using an empennage-mounted pylon/pod would involve verification of the loads determination on the structural support system and analysis of the proposed support system configuration to ensure loads requirements are met. . Additionally a testing and qualification program would be required to certify the new modified pod. This option would be a substantial effort due to the complexity of modifying the empennage structure to accommodate the new attachments.

4.3.5.5 Reliability & Maintainability

R & M activities associated with SFMR integration using an empennage mounted pylon/pod would involve development of a preventive maintenance program to purge the receiver enclosure with nitrogen gas and develop a plan for annual calibration of the SFMR. These activities will evolve with the development of an R&M Program Plan and update of the LSAR Database for the WC-130J.

4.3.5.6 Safety

Safety activities associated with SFMR integration using an empennage mounted pylon/pod would involve an assessment of the design with respect to flight limitations associated installation of a pylon/pod on the empennage.

4.3.5.7 Software/Avionics

Software/avionics activities associated with SFMR integration using an empennage mounted pylon/pod would involve coordination with the vendor and EMI to determine all of the intercommunication aspects of the design.

4.4 Configuration – Fuselage Installation, Fwd/Aft Orientation

4.4.1.1 Description

The fuselage mounted SFMR for this study shall be located in the area previously occupied by the AN/APN218 Doppler antenna (on center between FS 277 & FS 317). This area was selected for study since this location has been used in the past and is therefore a proven concept. Other fuselage mounting locations exist where this device could be installed. Also, this study will address the orientation of the device as Fwd/Aft.

The SFMR will be mounted to support structure built up between floor bulkheads. A penetration will be made in the lower fuselage skin and a fairing will be required to provide a protective covering for the SFMR as it protrudes through the cutout. Internally, a pressure box will have to be built up to surround the SFMR and its support structure. An access panel will be built into the pressure box to provide access to the unit.

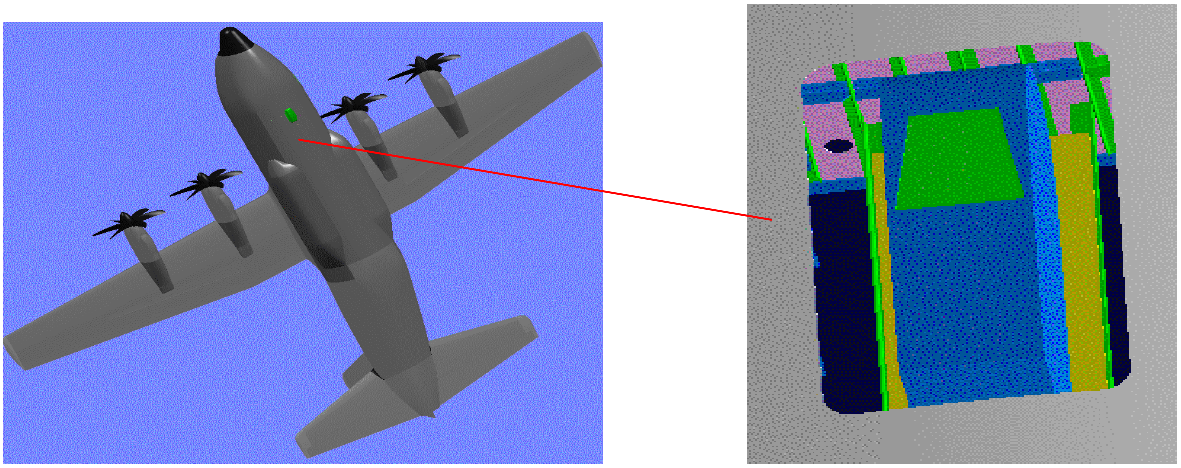


Figure 40 – Fuselage Installation, Fwd/Aft Orientation of SFMR

4.4.1.2 Construction

The installation configuration for an SFMR that is oriented Fwd/Aft will be more complex than the installation for a unit oriented Inbd/Outbd since more primary structure is affected. In developing a structural support configuration, the Fwd/Aft oriented unit will require that a primary rib at FS 296 be spliced as part of the cutout to permit the SFMR to “look through” the lower surface. In addition, 2 secondary ribs at FS 287 & FS 307 will require splicing and a major modification to the bulkhead at FS 296 is required to allow the device to feed through at this location. This complicates the issue of moving load around the cutout and thereby increases the complexity of the pressure box for that houses the SFMR.

The pressure box assembly will provide a means for supporting the SFMR and access to the unit will be through a removable panel in the top. A framework structural support system would be integral to the pressure box. It would be mechanically fastened to the upper panel of the pressure box. The support structure that makes up the pressure box and the SFMR support system would be fabricated utilizing 6061 aluminum sheet and extrusion stock. The SFMR unit would be attached at hard points to shock mounts.

Removal of the unit is made possible by removing a fairing that is attached to the OML of the lower surface of the aircraft. The fairing could be made of a suitable composite material such as carbon fiber composite or fiberglass reinforced plastic. A radome, fashioned of a material such as what is currently used on the SFMR (Rexolite) or equivalent would be provided in the fairing. The radome provides a weather resistant barrier that permits antenna reception.

4.4.2 Impact - Fuselage Installation, Fwd/Aft Orientation

4.4.2.1 Structures

Major structural modifications will be required to integrate this system into the aircraft fuselage. Bulkhead modifications and pressure box installation will demand extensive structural enhancement for the Fwd/Aft oriented SFMR configuration. The cutout in the fuselage will require that a “picture framing” approach be taken to move the loads around the cutout.

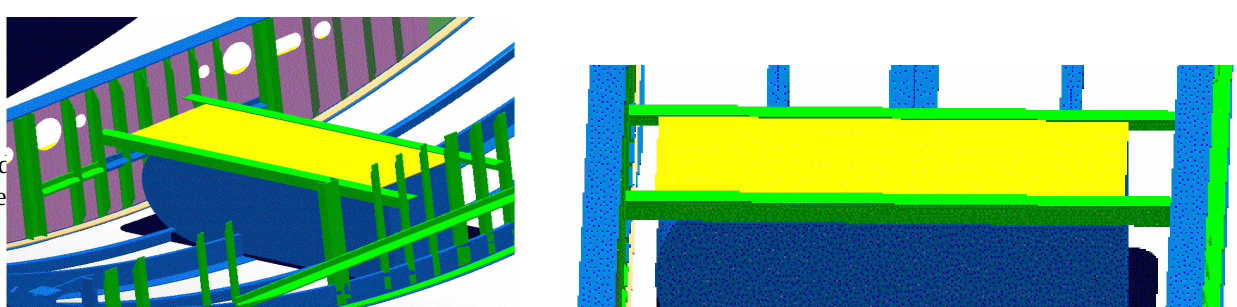


Figure 41 – Fuselage Installation, Fwd/Aft Orientation Structural Support Concept Systems

The development of the support system configuration is dependent upon the location of hard points within the SFMR. The usage of appropriately sized shock mount isolators will provide a measure of control with respect to vibration. The structural support renditions are simple at best and based on pictures provided by the vendor, ProSensing.

4.4.2.3 Operations

Modification to the ECS ducting local to the area where the pressure box is built up may be required. The ducting may need to be rerouted around the pressure box.

Access to the SFMR unit would be gained through a removable panel in the top of the pressure box. As stated before, removal of the unit is made possible by removing a fairing that is attached to the OML of the lower surface of the aircraft. The SFMR should be able to be removed from the support system at the shock mount isolators. This would provide easy access for periodic maintenance such as calibration. Quick disconnects should be provided at the shock mount isolators adjacent to the structural mounting location.

The SFMR unit does not require environmental control since it is a self-contained unit that has built-in failsafe features to prevent overheating, limit power consumption and provide electronic heating to maintain system calibration.

The wire routing for the system interconnection can pass through the pressure box barrier outboard and up through the floor to the ARWO station. The wire routing has to be assessed to ensure that the external cables are not routed along side other cable that carry high electric current. The routing should not exceed 200 feet in length. Shielded cable should be considered for use with this system.

4.4.3 Benefits - Fuselage Installation, Fwd/Aft Orientation

The benefits associated with incorporation of the SFMR system into the WC-130J fuselage include minimization of aerodynamic and range impact. Also, the proposed configuration would not require removal for performance of alternative mission requirements. Another benefit is that the concept of mounting antenna systems in this location is proven. The development of a pressure box and support structure system to house the SFMR is similar to the approach used to install the AN/APN218 Doppler antenna and therefore lessons learned can be applied to the design.

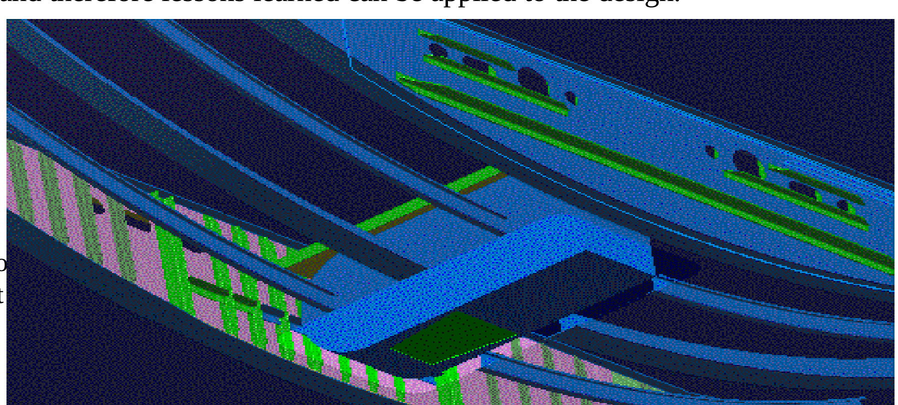


Figure 42 – Cutaway View of Fwd/Aft Fuselage Installation

4.4.4 Risks - Fuselage Installation, Fwd/Aft Orientation

The risks associated with incorporation of the SFMR system into the WC-130J fuselage include location in proximity to radiation sources. The fuselage mounting location has to be assessed for electromagnetic interference by conducting a spectrum analysis to determine operational system impact. Other risks include obstruction of the radome. The radome may be subject to exposure to contaminants (oil, fuel etc.) on the underside of the aircraft due to the proximity of the installation to the ground.

4.4.5 Analysis & Test Issues

4.4.5.1 Aerodynamics

Aero activities associated with SFMR integration using a fuselage installation location would involve coordinating with design to develop the fairing shape used to protect the device as it protrudes through the bottom surface of the aircraft.

The drag for this configuration is small resulting in less than 1% reduction in cruise range.

4.4.5.2 EMI

EMI activities associated with SFMR integration using a fuselage installation location would involve conducting a spectrum analysis of the aircraft and determining the impact to the system through coordination with the vendor and avionics/software.

4.4.5.3 Vibroacoustics/Loads

Vibro/loads activities associated with SFMR integration using a fuselage installation location would involve analysis of the proposed design for weight and balance effects. Vibro/loads will have to develop the structural and vibroacoustic loads on the support structure as well as sizing of vibration isolators that interface between the structural support system and the SFMR. The vibro/loads effects for the Fwd/Aft oriented system would also have to be analyzed to determine the structural support capability to spread the load around the cutout. This effort would be quite substantial due to the complexity involved with modifying the primary fuselage structure.

4.4.5.4 Stress

Stress analysis activities associated with SFMR integration using a fuselage installation location would involve verification of the loads determination on the structural support system and analysis of the proposed support system configuration to ensure loads requirements are met. This effort would be quite substantial due to the complexity involved with modifying the primary fuselage structure.

4.4.5.5 Reliability & Maintainability

R & M activities associated with SFMR integration using a fuselage installation location would involve development of a preventive maintenance program to purge the receiver enclosure with nitrogen gas and develop a plan for annual calibration of the SFMR.. These activities will evolve with the development of an R&M Program Plan and update of the LSAR Database for the WC-130J.

4.4.5.6 Safety

Safety activities associated with SFMR integration using a fuselage installation location would involve an assessment of the design with respect to maintaining pressurization in the cargo compartment.

4.4.5.7 Software/Avionics

Software/avionics activities associated with SFMR integration using a fuselage installation location would involve coordination with the vendor and EMI to determine all of the intercommunication aspects of the design.

4.5 Configuration – Fuselage Installation, Inbd/Outbd Orientation

4.5.1.1 Description

The fuselage mounted SFMR for this study shall be located in the area previously occupied by the AN/APN218 Doppler antenna (on center between FS 277 & FS 317). This area was selected for study since this location has been used in the past and is therefore a proven concept. Other fuselage mounting locations exist where this device could be installed.

The SFMR will be mounted to support structure built up between floor bulkheads. A penetration will be made in the lower fuselage skin and a fairing will be required to provide a protective covering for the SFMR as it protrudes through the cutout. Internally, a pressure box will have to be built up to surround the SFMR and its support structure. An access panel will be built into the pressure box to provide access to the unit.

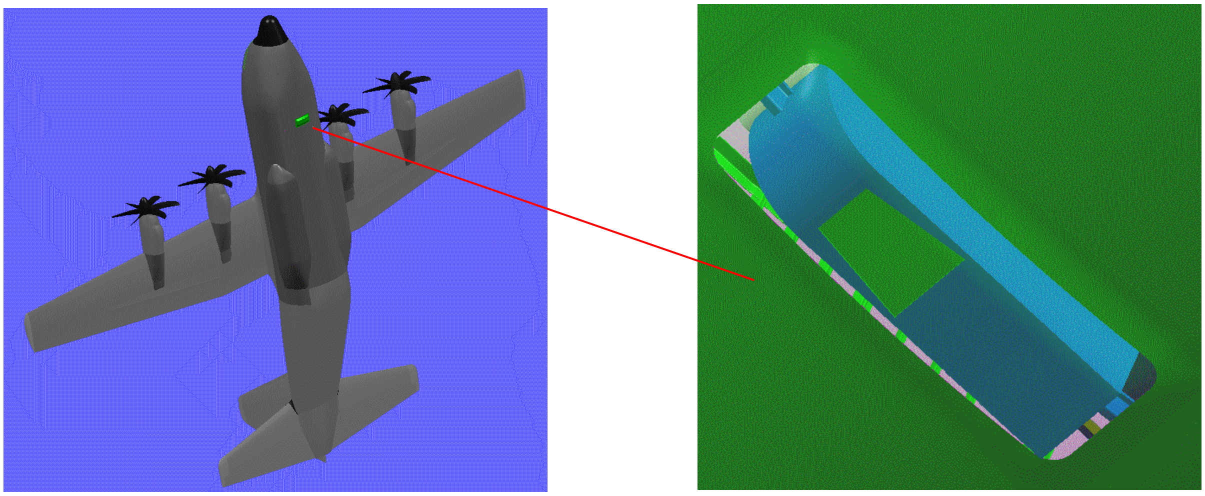


Figure 43 – Fuselage Installation, Inbd/Outbd SFMR Orientation

4.5.1.2 Construction

The installation configuration for an SFMR that is oriented Inbd/Outbd will require that 1 intermediate rib be spliced. In developing a structural support configuration, the Inbd/Outbd oriented unit will also require a cutout to permit the SFMR to "look through" the lower surface. This complicates the issue of moving load around the cutout and thereby increases the complexity of the pressure box for the SFMR. However, major modifications to aircraft primary structure will be minimized since the unit will nest between the bulkheads at FS 296 and FS 277. The box can be assembled between the bulkheads with a splice required at the FS 287 ring frame.

The pressure box assembly will provide a means for supporting the SFMR and access to the unit will be through a removable panel in the top. A framework structural support system would be integral to the pressure box. It would be mechanically fastened to the upper panel of the pressure box. The support structure that makes up the pressure box and the SFMR support system would be fabricated utilizing 6061 aluminum sheet and extrusion stock. The SFMR unit would be attached at hard points to shock mounts.

Removal of the unit is made possible by removing a fairing that is attached to the OML of the lower surface of the aircraft. The fairing could be made of a suitable composite material such as carbon fiber composite or fiberglass reinforced plastic. A radome, fashioned of a material such as what is currently used on the SFMR (Rexolite) or equivalent would be provided in the fairing. The radome provides a weather resistant barrier that permits antenna reception.

4.5.2 Impact - Fuselage Installation, Inbd/Outbd Orientation

4.5.2.1 Structures

Major structural modifications will be required to integrate this system into the aircraft fuselage. Bulkhead modifications are minimized for the Inbd/Outbd configuration but pressure box installation will demand extensive structural enhancement for either configuration. The cutout in the fuselage will require that a "picture framing" approach be taken to move the loads around the cutout.

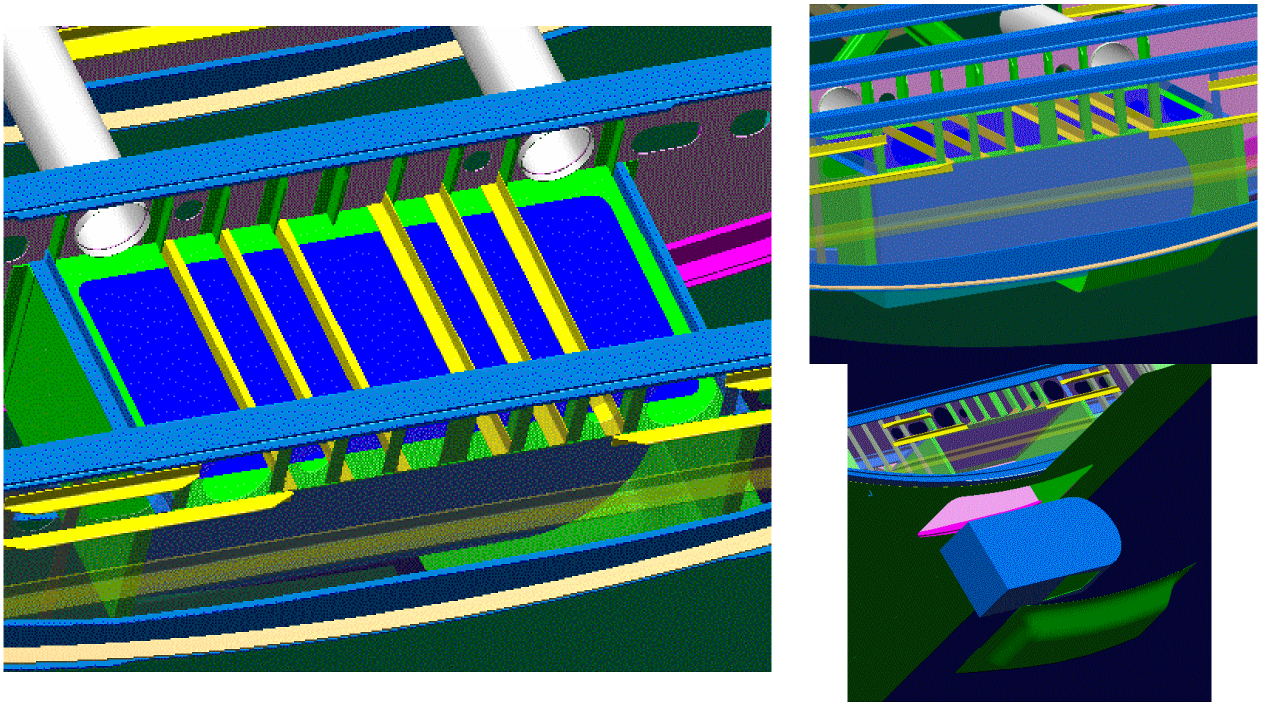


Figure 44 – Fuselage Installation, Inbd/Outbd Orientation Structural Support Concept

4.5.2.2 Systems

The development of the support system configuration is dependent upon the location of hard points within the SFMR. The usage of appropriately sized shock mount isolators will provide a measure of control with respect to vibration. The structural support renditions are simple at best and based on pictures provided by the vendor, ProSensing.

4.5.2.3 Operations

Modification to the ECS ducting local to the area where the pressure box is built up may be required. The ducting may need to be rerouted around the pressure box.

Access to the SFMR unit would be gained through a removable panel in the top of the pressure box. As stated before, removal of the unit is made possible by removing a fairing that is attached to the OML of the lower surface of the aircraft. The SFMR should be able to be removed from the support system at the shock mount isolators. This would provide easy access for periodic maintenance such as calibration. Quick disconnects should be provided at the shock mount isolators adjacent to the structural mounting location.

The SFMR unit does not require environmental control since it is a self-contained unit that has built-in failsafe features to prevent overheating, limit power consumption and provide electronic heating to maintain system calibration.

The wire routing for the system interconnection can pass through the pressure box barrier outboard and up through the floor to the ARWO station. The wire routing has to be assessed to ensure that the external cables are not routed along side other cable that carry high electric current. The routing should not exceed 200 feet in length. Shielded cable should be considered for use with this system.

4.5.3 Benefits - Fuselage Installation, Inbd/Outbd Orientation

The benefits associated with incorporation of the SFMR system into the WC-130J fuselage include minimization of aerodynamic and range impact. Also, the proposed configuration would not require removal for performance of alternative mission requirements. Another benefit is that the concept of mounting antenna systems in this location is proven. The development of a pressure box and support structure system to house the SFMR is similar to the approach used to install the AN/APN218 Doppler antenna and therefore lessons learned can be applied to the design.

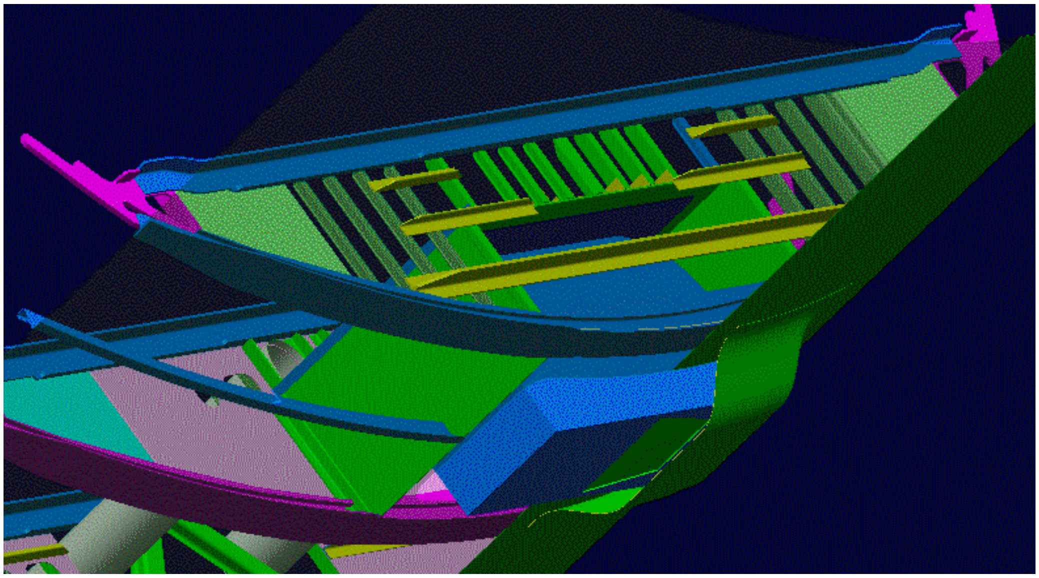


Figure 45 – Cutaway View of Inbd/Outbd Fuselage Installation

4.5.4 Risks - Fuselage Installation, Inbd/Outbd Orientation

The risks associated with incorporation of the SFMR system into the WC-130J fuselage include location in proximity to radiation sources. The fuselage mounting location has to be assessed for electromagnetic interference by conducting a spectrum analysis to determine operational system impact. Other risks include obstruction of the radome. The radome may be subject to exposure to contaminants (oil, fuel etc.) on the underside of the aircraft due to the proximity of the installation to the ground.

4.5.5 Analysis & Test Issues

4.5.5.1 Aerodynamics

Aero activities associated with SFMR integration using a fuselage installation location would involve coordinating with design to develop the fairing shape used to protect the device as it protrudes through the bottom surface of the aircraft.

The drag for this configuration is small, but will be slightly higher than the fwd/aft configuration due to the increased frontal area.

4.5.5.2 EMI

EMI activities associated with SFMR integration using a fuselage installation location would involve conducting a spectrum analysis of the aircraft and determining the impact to the system through coordination with the vendor and avionics/software.

4.5.5.3 Vibroacoustics/Loads

Vibro/loads activities associated with SFMR integration using a fuselage installation location would involve analysis of the proposed design for weight and balance effects. Vibro/loads will have to develop the structural and vibroacoustic loads on the support structure as well as sizing of vibration isolators that interface between the structural support system and the SFMR. The vibro/loads effects would also have to be analyzed to determine the structural support capability to spread the load around the cutout. This effort would be quite substantial due to the complexity involved with modifying the primary fuselage structure.

4.5.5.4 Stress

Stress analysis activities associated with SFMR integration using a fuselage installation location would involve verification of the loads determination on the structural support system and analysis of the proposed support system configuration to ensure loads requirements are met. This effort would be quite substantial due to the complexity involved with modifying the primary fuselage structure.

4.5.5.5 Reliability & Maintainability

R & M activities associated with SFMR integration using a fuselage installation location would involve development of a preventive maintenance program to purge the receiver enclosure with nitrogen gas and develop a plan for annual calibration of the SFMR. These activities will evolve with the development of an R&M Program Plan and update of the LSAR Database for the WC-130J.

4.5.5.6 Safety

Safety activities associated with SFMR integration using a fuselage installation location would involve an assessment of the design with respect to maintaining pressurization in the cargo compartment.

4.5.5.7 Software/Avionics

Software/avionics activities associated with SFMR integration using a fuselage installation location would involve coordination with the vendor and EMI to determine all of the intercommunication aspects of the design.

5.0 SFMR Integration Study - Design Down Select

5.1 Configuration Selection

5.1.1 Scoring system

A technique called Pair Wise was used to document and tabulate scoring for the Configuration trades. Consistency was measured for each trade, as discussed in an IEEE article titled "A Cost-Value Approach for Prioritizing Requirements" by Joachim Karlsson and Kevin Ryan, dated Sep/Oct 1997. Pair Wise monitors the consistency ratio during scoring and allows the scorer to readily examine and modify inconsistent scores. The Pair Wise technique also provides a detailed audit trail for post-examination of the scoring as well. This data is contained in the appendix.

5.1.1.1 Scoring categories

1) Ease of Installation - Effort required to configure the aircraft for the Weather bird mission, this does not include the initial effort required to modify the aircraft to accept the SFMR unit.

2) Ease of Removal - SOW Item 4.10 - Effort required to reconfigure the aircraft for the combat delivery mission once SFMR has been installed.

3) Performance effects - SOW Item 4.7 – Effect of design on Airspeed limitations, Range and Loiter time Reduction.

4) Safety – SOW Item 4.8 – A comparison of the design options looking at penetration of pressurized skins, additional aero loads and possible failure modes.

5) EMI environment – SOW Item 4.9 - Proximity of the SFMR unit to interfering transmitters and equipment

6) Reliability & Maintainability – SOW Item 4.11 - Evaluate access to system components for repair or replacement and complexity of design looking especially at support structure

7) Technical Risk - Complexity of design in comparison to past design efforts and proximity to other aircraft systems which might have to be relocated, favoring concepts that make use of existing similar design concepts.

8) Schedule Risk - scope of design task, including new parts and assemblies required and involvement of secondary vendors.

Criteria Weighting

Once the Scoring categories had been determined they were compared against each other to come to a relative weighting of importance. This was then normalized to yield a total score of 100. This resulted in the following:

1)	Technical Risk	35.8
2)	Performance	25.4
3)	EMI Environment	13.4
4)	Ease of Installation	6.4
4)	Ease of Removal	6.4
4)	Reliability & Maintainability	6.4
7)	Safety	4.2
8)	Schedule Risk	1.9

5.1.1.3 Summary of Option Scores

Stepped Frequency Microwave Radiometer Integration Study	Technical Risk	EMI Environment	Performance	Ease of Installation	Ease of Removal	Reliability & Maintainability	Safety	Schedule Risk	TOTAL
Wing Installation, Pod/Pylon Mounted SFMR	**18.6**	**7.7**	5.1	1.3	1.5	1.3	**1.8**	0.1	**37.3**
Fuselage Installation	7.2	0.7	**13.3**	**3.3**	**2.5**	**3.3**	0.8	1.1	32.1
Empennage Installation, Pod/Pylon Mounted SFMR	7.2	1.1	5.1	1.3	1.9	1.3	0.5	**0.5**	18.9
Wing Installation, Fuel Tank Mounted SFMR	2.8	3.9	1.9	0.5	0.6	0.5	1.2	0.2	11.6
TOTAL	35.8	13.4	25.4	6.4	6.4	6.4	4.2	1.9	**100**

Table 9 - Design Concept Category scores and Totals

Technical Risk – The rationale for the scores in this category was that Pod/Pylon mounted installation would be not require any new design concepts to be developed, such as the Fuel Tank or Empennage, nor would cause any rework to existing structure or system installations.

EMI Environment – The scores for this category follow each option's proximity to the emitting sources that are found on the aircrafts fuselage, principally along the centerline.

Performance – Overall increase in vehicle drag was the primary consideration for the options in this case with a knockdown for the decreased fuel capacity Fuel Tank Mod counted against that option.

Ease of installation/ Ease of Removal – Discounting the labor required to do the initial modification to install the option and looking solely at the effort to install/remove the SFMR unit each time the aircraft is configured for the Weatherbird mission it was felt that the Fuselage option could be installed by a single mechanic using basic hand tools whereas the other options due to their size and location would need additional personnel and/or special cradles and stands to accomplish these tasks.

Reliability & Maintainability – The scores here were based on the thought that the access to the SFMR unit and ease of repair to damaged support structure are the driving factors. Here the easy access that the fuselage option provides to the SFMR unit gave it the highest score in this area.

Safety – Penetration of the vehicle pressure boundary was the primary factor in determining scores for this category. Based on that the Wing mounted options, which do not affect this boundary scored the highest. But when the two options were evaluated against each other the fact that the Fuel Tank Mod would require designing a path through the fuel volume for electrical power lines pushed it behind the Outer Wing Pod/Pylon option.

Schedule – Although this was the least weighted of the categories Lockheed feels it's an area that should be addressed. Scores here were based on the number of new design concepts that would have to be developed, how much could be acquired as COTS or adapted from past designs and the number of possible vendors that would be involved in the project.

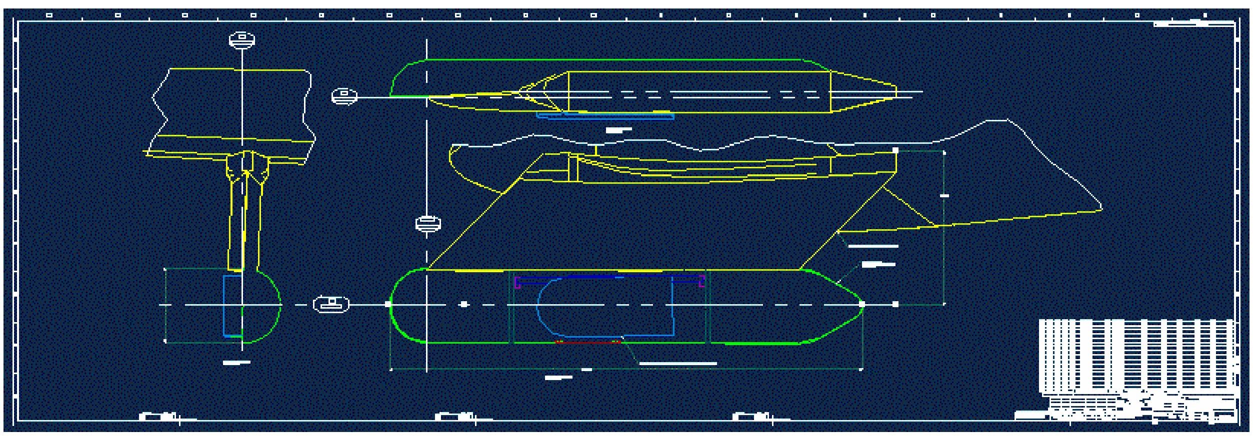
Based on the summary above the selected option to integrate the SFMR unit into the WC-130J is to use a pylon and pod mount at outer wing station 330.10.

5.2 Summary of Integration Issues for Down Selected Concept

The largest issue for this design will be managing the creation and integration of a new vendor produced pod with Prosensing's SMFR unit and a COTS pylon. Of a smaller concern is the wiring runs and disconnects that will be required to install the unit.

Providing a vendor with design drawings for the surface definition and interface requirements for the new pod to house the SFMR unit will produce the bulk of the engineering effort required from Lockheed.

5.3 Line Drawings



Preliminary sketches for the installation of the new pod and SFMR unit have been completed as shown above and loft data for the vendor, presumably Zivko, could be made readily available should it be decided to pursue this option. Wiring drawings are already in existence for the Aerial Refueling pod installations and can be readily revised and adapted for this system.

6.0 Conclusions

6.1 Summary Discussion of Configuration Risks and Benefits

6.1.1 Risks

The only risks associated with the selected configuration are possible airspeed and range reductions caused by the drag and weight of the pylon and pod structure. Neither of these is anticipated to be difficult to overcome with careful design of the pod shape. An additional area of project risk will be coordinating the various interfaces of vendors' assemblies to support the implementation schedule for the installations.

6.1.2 Benefits

The benefits of this choice include quick and easy removal of the SFMR pylon and pod for reconfiguring the aircraft to the combat delivery mission. A minimum of modification to the existing aircraft structure and systems has to be performed. The design is similar to the Aerial Refueling pod and lessons learned from that program will be applied to this project.

6.2 Implementation Strategy

6.2.1 Pylon

Lockheed to review and approve the use of a Sargent Fletcher Universal Pylon (P/N 400666) or equivalent.

6.2.2 Pod Development

Lockheed to produce Pod Requirements for vendor designed (Zivko) pod. Catia Model to include definition of aerodynamic surfaces, interface of pylon and SFMR attachments.

6.2.3 Source Control Drawing

Lockheed to produce a Source Control Drawing for SFMR Pylon/Pod similar to FRL Refueling Pod.

6.2.4 Vendor Coordination.

Lockheed required to monitor development of interface between Zivko - Sargent Fletcher and Zivko - Prosensing) components of vendor assemblies to assure components arrive on schedule and assemble together correctly.

6.2.5 Wiring

Lockheed to provide wiring drawings for SFMR from Pylon station along Trailing edge of wing to BL 61 Bulkhead, similar to wiring runs for Refueling pod.

Lockheed to provide wiring drawings for installation of wiring harnesses from BL 61 Bulkhead to the ARWO computer.

6.2.6 Proof of Concept

Lockheed to do Kit Installation Test at Marietta and revise Top Kit for WC-130J.

6.3 Conclusion

Based on the data collected on the SFMR unit and the looking at all of the possible locations it appears that the WC-130J could be modified to incorporate this unit on the outer wing pod/pylon with a minimum of modification to the aircraft structure, systems and software. The incorporation of this option would provide a easy on / off type of installation that would not include any new pressure vessel penetrations, place the SFMR unit as far as possible from emitting equipment and in an optimal position to perform its primary function.

Appendices

Appendix A: Questions and Concerns from 1 April 2003 Technical Interface Meeting in Marietta, GA

Has the unique configuration of the WC-130J been considered in the evaluation of the of the EMI environment for each of the possible installation locations?

Yes - the SFMR system was reviewed against all of the unique WC-130J equipment including the HF Comm, SATCOM GPS Antenna and C Band Radar Altimeter, and it was found that with proper shielding of the unit and its wiring, it should perform acceptably. For the C Band Radar Altimeter, however; ProSensing said that no matter where on the aircraft the unit was mounted, they would need a flight test program using a spectrum analyzer to measure the RFI at the chosen location. It would then require shifting of frequencies within the device and/or generation of a blanking pulse and additional testing before the SFMR could be qualified.

What have been the lessons learned from the past installations of the SFMR in the NOAA fleet been?

From the NOAA fleet we were able to identify the previously mentioned problem with the HF Comm as well as its sensitivity to all emissions from the aircraft systems in verifying the maintenance history of the SFMR unit.

Has the unique configuration of the WC-130J been considered in the evaluation of the of the aircraft CG changes for each of the possible installation locations?

Yes - these installations were reviewed against the WC-130J CG envelope and found to be acceptable based on the positions and added masses they would impart to the aircraft.

Has the unique configuration and mission of the WC-130J been considered in the evaluation of the of aircraft performance for each of the possible installation locations?

Yes – aerodynamic considerations of the WC-130J were evaluated for the three pod and the one fuselage mounted installations against the mission airspeed, range and loiter time requirements.

What is the effect of an external Pod installation on the mission duration (TOS) requirement of 10 hours?

Preliminary answer from LM Aerodynamics/Performance for the SFMR pod mounted on the wing: Due to the 5 drag counts (including the rudder trim drag impact) and 200 *pound weight increase assigned to this pod – the 10 hour required mission time (TOS) would be reduced by approx. 10 minutes.*

Do the valuations given to the EMI and Performance scored categories accurately reflect the operational characteristics and mission profile for the WC-130J?

Yes – after consideration of the comments expressed at the TIM regarding the Performance and EMI category weights, they were reversed to reflect their relative values to the operation of the SFMR unit for the WC-130J mission.

What are the peculiar support needs of the SFMR equipment?

Answer provided by ProSensing and NOAA personnel: 'Yearly calibrations are currently accomplished at the vendors' laboratory.' 'Aircraft removal and replacements conducted on a cycle shorter than one year would need an operational check of the equipment at installation.'

Appendix B: Preliminary Down Select data – scoring per category

Scoring

Capabilities are of equal value	1	1.00
Slightly more capable	3	0.33
Experience and capability strongly favors one	5	0.20
One is strongly favored and demonstrated in practice vs. another	7	0.14
Over whelming evidence favoring one over another	9	0.11
2,4,6,8 Values used only when compromise is needed.		
Numbers in the shaded areas are the inverse of those in the white areas.		

"Stepped Frequency Microwave Radiometer Integration Study"	Ease of Installation: Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	0.33	0.20	0.20	0.33	0.05
Outer Wing Pylon Pod	3.03	1.00	0.33	0.33	1.00	0.13
Fuselage Pressure Box	5.00	3.03	1.00	1.00	5.00	0.37
Empennage Pressure Box	5.00	3.03	1.00	1.00	3.00	0.33
Empennage Pod	3.03	1.00	0.20	0.33	1.00	0.12
	17.06	8.39	2.73	2.86	10.33	1.00

Consistency Ratio
0.03

"Stepped Frequency Microwave Radiometer Integration Study"	Ease of Removal (SOW Item 4.10)						Score
	Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod		
Inner Wing Fuel Tank Pod	1.00	0.33	0.33	0.33	1.00		0.09
Outer Wing Pylon Pod	3.03	1.00	0.33	1.00	3.00		0.22
Fuselage Pressure Box	3.03	3.03	1.00	1.00	3.00		0.34
Empennage Pressure Box	3.03	1.00	1.00	1.00	1.00		0.22
Empennage Pod	1.00	0.33	0.33	1.00	1.00		0.12
	11.09	5.69	2.99	4.33	9.00		1.00
	Consistency Ratio						
	0.07						

"Stepped Frequency Microwave Radiometer Integration Study"	Performance (SOW Item 4.7)						Score
	Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod		
Inner Wing Fuel Tank Pod	1.00	0.33	0.33	0.33	0.33		0.07
Outer Wing Pylon Pod	3.03	1.00	0.33	0.33	1.00		0.16
Fuselage Pressure Box	3.03	3.03	1.00	0.33	0.33		0.18
Empennage Pressure Box	3.03	3.03	3.03	1.00	0.33		0.26
Empennage Pod	3.03	1.00	3.03	3.03	1.00		0.34
	13.12	8.39	7.72	5.02	2.99		1.00
	Consistency Ratio						
	0.18						

"Stepped Frequency Microwave Radiometer Integration Study"	Safety (SOW Item 4.8) Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	0.33	3.00	3.00	3.00	0.27
Outer Wing Pylon Pod	3.03	1.00	5.00	3.00	1.00	0.36
Fuselage Pressure Box	0.33	0.20	1.00	1.00	0.33	0.07
Empennage Pressure Box	0.33	0.33	1.00	1.00	0.33	0.08
Empennage Pod	0.33	1.00	3.03	3.03	1.00	0.22
	5.03	2.86	13.03	11.03	5.66	1.00
	Consistency Ratio					
	0.09					

"Stepped Frequency Microwave Radiometer Integration Study"	EMI environment (SOW Item 4.9) Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	0.33	7.00	5.00	3.00	0.27
Outer Wing Pylon Pod	3.03	1.00	9.00	7.00	3.00	0.47
Fuselage Pressure Box	0.14	0.11	1.00	0.33	0.20	0.04
Empennage Pressure Box	0.20	0.14	3.03	1.00	0.33	0.07
Empennage Pod	0.33	0.33	5.00	3.00	1.00	0.15
	4.71	1.92	25.03	16.33	7.53	1.00
	Consistency Ratio					
	0.05					

"Stepped Frequency Microwave Radiometer Integration Study"	Reliability & Maintainability (SOW Item 4.11) Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	0.33	0.20	0.20	0.33	0.06
Outer Wing Pylon Pod	3.03	1.00	0.33	1.00	1.00	0.16
Fuselage Pressure Box	5.00	3.03	1.00	3.00	3.00	0.43
Empennage Pressure Box	5.00	1.00	0.33	1.00	3.00	0.23
Empennage Pod	3.03	1.00	0.33	0.33	1.00	0.13
	17.06	6.36	2.20	5.53	8.33	1.00
	Consistency Ratio					
	0.05					

"Stepped Frequency Microwave Radiometer Integration Study"	Technical Risk Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	0.33	0.33	1.00	0.33	0.09
Outer Wing Pylon Pod	3.03	1.00	3.00	3.00	1.00	0.34
Fuselage Pressure Box	3.03	0.33	1.00	1.00	1.00	0.17
Empennage Pressure Box	1.00	0.33	1.00	1.00	3.00	0.20
Empennage Pod	3.03	1.00	1.00	0.33	1.00	0.20
	11.09	3.00	6.33	6.33	6.33	1.00
	Consistency Ratio					
	0.14					

"Stepped Frequency Microwave Radiometer Integration Study"	Schedule Risk: Inner Wing Fuel Tank Pod	Outer Wing Pylon Pod	Fuselage Pressure Box	Empennage Pressure Box	Empennage Pod	Score
Inner Wing Fuel Tank Pod	1.00	3.00	0.14	0.20	3.00	0.12
Outer Wing Pylon Pod	0.33	1.00	0.20	0.33	1.00	0.07
Fuselage Pressure Box	7.14	5.00	1.00	1.00	7.00	0.42
Empennage Pressure Box	5.00	3.03	1.00	1.00	5.00	0.33
Empennage Pod	0.33	1.00	0.14	0.20	1.00	0.06
	13.81	13.03	2.48	2.73	17.00	1.00

Consistency Ratio
0.08